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Relative Efficacy of Treatment Strategies for Functional Misarticulation in Preschool Children: Sensory-Motor and Cognitive Approaches.

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RELATIVE EFFICACY OF TREATMENT STRATEGIES FOR
FUNCTIONAL MISARTICULATION IN PRE-SCHOOL CHILDREN:
SENSORY-MOTOR AND COGNITIVE APPROACHES

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by

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ABSTRACT

The present study investigated learning rate differences relative to number of sessions necessary to reach a terminal criterion on /s/ production accuracy by four pre-school functional misarticulators under two different treatment approaches; a sensory motor approach and a cognitive-communicative approach. Phonetic transcriptions of the misarticulator's productions of a forty item word and connected speech generalization probe administered continuously over treatment was used to determine percentage of correct productions. Probe items included /sC-/, /sCV-/, /-Vs/, and /-VCs/ single syllable word shapes. These four and five year old misarticulating subjects who produced stop consonants for [s] were also compared with four normal subjects of the same age in performance on both auditory perceptual measures involving the stop-continuant contrast, and on spectrographic measures of mean duration and variability involving productions of intervocalic /s/ singletons and /s/ clusters. Experimental subjects also produced intervocalic stop consonants for within group duration comparisons with /s/ productions at pre-treatment. Misarticulating

measures of mean duration and variability involving productions of intervocalic /s/ singletons and /s/ clusters. Experimental subjects also produced intervocalic stop consonants for within group duration comparisons with /s/ productions at pre-treatment. Misarticulating subject's performances were compared to normal subject's performances on the /s/ measures at pre-; mid- and post-treatment; and were compared to the normals on the auditory perceptual measures at pre- and post-treatment. Normal subjects were tested only once on the speech production measures and the auditory perceptual measures.

Subjects in the Cognitive approach attained a sustained level of accuracy of production of [s] in connected speech earlier than their sensory-motor matches. Other treatment related findings which occurred across all misarticulators included emergence of /-Vs/ syllable shape first; attainment of 75% production accuracy of [s] in single words and connected speech simultaneously on an intrasubject basis.

Misarticulators performed similarly to normals on auditory perceptual tasks at pre-treatment, though they differed from normals on the speech production duration measures at all three points in time. The misarticulators at pre-treatment evidenced mean durations which

CHAPTER I

REVIEW OF THE LITERATURE

Traditional remediation programs for children's functional misarticulation were developed to increase the child's phonetic production skills (Van Riper, 1939; McDonald, 1964; Winitz, 1975). Procedures evolved using theoretical speech motor control and perceptual units such as articulatory features, speech sound segments, syllables and syntagmas. The basic thrust of such programs was to develop the child's ability to perceive, produce and judge the adequacy of speech sound productions in hierarchically arranged combinations of these putative motor control units. The ultimate therapeutic goal was for the child to automatize appropriate production of the error sound. Intervening therapeutic goals often involved self-judgment of the adequacy of these productions. Evidence in favor of the phonetic level approach to functional misarticulation has been derived from two main sources- effects of phonetic context upon rates of misarticulation and evidence that functionally misarticulating children show subtle, perhaps idiosyncratic deficits in oral sensory-motor processing.

More recently, there has been a paradigmatic shift in the study of children's functional misarticulation which emphasizes cognitive level processing over the sensory motoric domain (Ingram, 1976; Dinnsen, 1984; Shriberg and Kwiatkowski, 1980). Functional misarticulation is thought to result from the child's failure to organize his sound production system in accordance with the phonology of the parent language. Essentially, it is hypothesized that some aspects of the phonology of the parent language are mislearned by the child. Evidence favoring this viewpoint includes demonstrations of systematic error patterns in children's functional misarticulations which appear to be rule governed in nature. Therapeutic intervention teaches the underlying phonological concepts which have been mislearned by presenting examples of missing phonemic contrasts which are then utilized in meaningful communicative interchanges (Cooper, 1968; Elbert and Geirut, 1986).

In part, the shift in emphasis from phonetic to phonological paradigms has been caused by changes in the population of functionally misarticulating children being treated. When the traditional, phonetic model was formulated, children were judged to be speech defective if they failed to correctly articulate all of the consonant sounds of English by their eighth birthday. This clinical judgment coincided with the use of 10th percentile performance criteria derived from the production of speech sounds in words by normally developing children, e.g. Poole (1934). More recently, preschool children whose speech is unintelligible due to numerous misarticulations have been targeted as an important clinical population. This younger, more severely impaired population may be misarticulating for quite different reasons than the older, school-age child (McNutt and Hamayan, 1984). Furthermore, the demands for metalinguistic judgment of speech sound production correctness demanded in the traditional approach may be beyond the cognitive reach of the younger population.

The central issue addressed in this study is the efficacy of these two broad approaches to the treatment of functional misarticulation in a group of preschool children. This group of preschool children demonstrated similar error patterns characterized by stopping of [s], (i.e. substitution of a stop consonant) when /s/ occurred as a singleton, and cluster reduction, (i.e. the deletion of [s] in /sC/ clusters). These preschoolers were divided into two groups. One group was treated in a traditional phonetic production practice regime. The second group was treated in a more cognitively-oriented, meaning-based, communicative program. Differential success of the two programs was measured by the amount of time taken for each program to result in the child's use of correct articulation of the targeted speech sound in conversational speech, the presumed end goal of all articulation programs. Potential differences were also measured in the child's ability to perceptually categorize error phonemes. It was thought that this phonemically based cognitive activity might be better learned in the cognitive based approach. Differences were also sought in measures of children's coarticulation of [s] with surrounding sounds, (i.e. duration of [s] in a variety of contexts). This is presumably a phonetic level production skill which should improve more dramatically as a result of the traditional approach.

The following literature review is divided into two sections - Traditional Phonetic Approaches and Phonological Approaches. Each section describes the basic therapeutic strategies, evidence from descriptive studies investigating various aspects of each approach and evidence from training studies which have assessed portions of each.

Traditional Phonetic Approaches

The basic tenet of the traditional approaches is that functional misarticulation results from disordered speech sound production or perception mechanisms. In order to discuss these approaches it is necessary to first present a model of the theoretical processing levels involved in speech production. In the following discussion, Kent and Minifies' (1977) speech production model is described. This is followed by a description of three speech sound production-based therapeutic strategies devised by Van Riper (1939), McDonald (1964) and Johnston, Goldberg, and

Mathers (1984). This description is followed by discussion of descriptive and experimental studies which have sought to demonstrate the validity of these procedures.

Physiological Model of Speech Production

Kent and Minifie (1977) devised a hierarchical model of speech production containing five levels of processing as seen in Figure 1.

The input to the speech production mechanism is a linguistically formulated utterance or part of an utterance corresponding to a unit of propositional meaning. This unit, known as a syntagma corresponds to up to approximately seven syllables (Kozhevnikov and Chistovich, 1966). This piece of an utterance will contain a representation of the phonemes to be uttered and their syllabic arrangement in words. An example utterance would be /aIm frəm nu arlinz/. The overall purpose of the following processing stages is to convert these static units into a dynamically changing well timed-pattern of neuromotor commands.

RHYTHMIC GROUPING OF SYLLABLES (multi-syllabic unit or phrases)
SYLLABLE FORM (individual syllable shapes and associated intrasyllabic rules)
PHONEME OR SEGMENT (basic phonetic constituents or syllable)
SET OF PHONETIC FEATURES (goals or targets defined for each phoneme or segment)
PATTERN OF ARTICULATORY TRANSITIONS (articulatory realizations of phonetic features)
SEQUENCE OF NEUROMOTOR COMMANDS (neural instructions to the muscles, derived from transitional requirements)

Figure 1. Kent and Minifie's hierarchical model of speech production

The highest level, Rhythmic Grouping of Syllables establishes the respiratory requirements for the utterance including inspiratory volume, pressure modulations necessary for required stress effects, and the timing of pauses for inspiration (Kent and Minifie, 1977, P. 131). Laryngeal function relative to the intonation contour of the utterance as well as temporal sequencing of phonetic components are also established at this level. In the example utterance one breath would be taken before the beginning of the utterance. Laryngeal adjustments would be made to stress the first syllable and to allow for a falling intonation pattern.

At the second level, Syllable Form, the speaker determines the syllable shapes that will comprise the utterance. It is assumed that the speaker has a variety of syllable structures to choose from, and Kent and Minifie emphasize the importance of flexibility in the selection process at this level. In the example, a speaker may choose to represent "New Orleans" as /nuwal nz/, or /nuarlinz/ or /nju rlInz/.

At the third level, phonemic organization provides the "basic phonetic constituents of the syllable". The writers stress that this is not the level of neuromotor commands. Next phonemes are defined relative to their minimal, necessary features such that the eventual phonetic distinctions necessary to the utterance can be made. The writers note that this is still a relatively abstract level in the process, and that a given feature may be attained by a variety of motor gestures. For example, vocal tract lengthening could be accomplished by either rounding the lips or lowering the larynx. This level provides a basis for the upcoming motor transitions that will be necessary.

At the next level the features are translated into articulatory transitions, which account for both position of articulators and timing of gestures. This level provides the information necessary for the generation of the neuromotor commands, the overall temporal plan for which will depend on those transitions which will have an immediate successional impact. In other words, "the minimal requirements for phonetic seriation are satisfied" (those movements critical to the utterance which "must follow one another in a prescribed sequence" (1977, p. 131) and following their specification, the non-prescribed transitions are fitted into the pattern. Less important features are coarticulated across segments to provide smooth transitions for each articulator.

At the last level then, the neural commands are derived and sequenced relative to the transition requirements. This final level involves choices among the various muscles which can contract in a particular direction. For example, both Temporalis and Masseter may contract to raise the mandible. A particular amount of contractile force will be chosen for each of these muscles to attain the desired movement.

Treatment Approaches

Van Riper's Traditional Therapy Strategy. The traditional orientation proposed by Van Riper (1939) is one which approaches functional misarticulation as correction of defective speech sound production. Misarticulations are remediated in a sound-by-sound fashion. The approach employs two major phases--"ear training" and "production training". Within the ear training phase, there are a number of steps. First the child is taught to recognize the target sound as spoken by adults. This is regarded as important because ability to recognize the target sound should enable the child to learn which words contain this sound. This ability is also important so that the child can learn the phonetic characteristics of the sound as spoken appropriately. Practice in this identification of the speech sound of interest can be broken into discrete steps in which the sound is recognized in isolation, syllabic productions, words, and sentences. The second stage of ear training involves teaching the child to discriminate the target sound from the error production that the child is using. For example, if a child produced [s] as [θ], he would be taught to discriminate the difference between these two sounds in syllables and word contexts.

During production training, the child practices production of his error phoneme in isolation, syllables, words, phrases, sentences, etc. During this production practice, the child is asked to listen to and judge his own productions for correctness. Van Riper endorsed the use of "key words", i.e., words in which the target sound is correctly articulated, as models for production practice and comparison to other productions for correctness. Van Riper also acknowledged a stage in production training in which the child must learn to "reconfigure" the words which he knows to include the target sound as opposed to the error sound which was used before therapy. This need to establish new sound patterns for words previously learned is similar to aspects of phonological learning which will be discussed in the following section.

Van Riper's approach is most directly related to the third level of Kent and Minifies' model. The misarticulating child is thought to have derived inappropriate phonetic features for the phonemes misarticulated. Stages in therapy represent attempts to teach the child to recognize these features in the speech of others and in the child's own productions. This information is then used by the child to scan for and correct errors in his own speech production. Van Riper did not advocate the use of extensive motor drill in this sequence, choosing rather to develop the child's self monitoring skills.

McDonald's Sensory-Motor Approach. McDonald (1964) developed the sensory-motor approach to articulation therapy. This approach offered a significant departure from earlier traditional testing and intervention strategies due to a number of salient features: its emphasis on the syllable rather than the phoneme as the basic speech unit; its consideration of the influence of phonetic context; and its heavy emphasis on the tactile and proprioceptive feedback in the speech production process. This approach stresses movement sequences in the speech production task in concert with McDonald's belief regarding error origin:

> It is our point of view that a misarticulated sound does not represent something 'wrong' which the child has learned. Rather a misarticulated sound represents an arrest in the development of specificity of sensory-motor function. In other words, a child misarticulates /s/, for example, because he is not properly responsive to the pattern of sensations associated with the movements which result in a correct /s/...misarticulated sounds result from inadequate sensory-motor interactions." (1964, p. 159).

Van Riper felt it necessary to extract the "speech sound" from the flow of speech so that the child could identify the "standard" sound and work to correct it. McDonald criticized this approach because speech sounds do not exist in isolation (1964, p. 181). McDonald observed also that the physical gestures involved in articulating a given sound vary with context and should be considered in that regard.

Rather than classifying consonants relative to their positions in words, syllabic position was used. If the consonant initiated the syllable it was referred to as a "releasing consonant". If the consonant terminated a syllable, it was considered to be an "arresting consonant". McDonald criticized the validity of earlier traditional tendencies to test consonants as occurring in initial, medial, and final positions of words. He attributed this consonant classification to the conceptualization of speech production as analagous to the orthographic representation of words and felt that such treatment was incompatible with the dynamic nature of speech production. Additionally, McDonald was critical of what he felt to be the exclusive "traditional" dependence on auditory awareness of the sound from an external source, suggesting that the child would progress better in therapy if his awareness was heightened relative to auditory, tactile, and proprioceptive aspects of his own correct production of the sound (1964, P. 183). McDonald adopted Fairbanks' servosystem model of speech production, a closed loop system. He described the central nervous system as the coordinator of all incoming information from the sensory processes (here described as the auditory, tactile, and proprioceptive end organs) to activate the motor processes (motor speech system) so as to provide for correct speech production by the speaker. His sensory-motor approach is a derivative, therefore, of his conceptualization of the speech production process.

McDonald designed both an assessment tool, the Deep Test of Articulation (McDonald, 1964) and an intervention approach. The test was designed to sample a given sound in a wide variety of phonetic contexts. In this way the target sound would be tested adjacent to vowels and consonants so as to obtain a representative speech sample for analysis. He used a systematic method of creating contexts in which the target consonants would occur such that contexts were either VCtC or CCtV (where Ct represents target consonant). From the test information the examiner would then determine the percentage of time in which the target sound was correctly produced, and in which contexts, known as facilitory contexts.

McDonald's therapy approach then was developed to capitalize on those aspects of speech production which he felt were most representative of the actual process itself. The overall design is one of progressively increasing complexity of movements in speech, beginning with procedures which he felt would serve "to heighten the child's responsiveness to the patterns of auditory, proprioceptive, and tactile sensations associated with the

p. 138). He begins with having the child imitate bisyllables composed of sounds the child produces correctly. Following all productions the child is requested to describe which articulators make contact with each other and the direction in which his tongue moves. The bisyllabic utterances are reduplicated syllable sets utilizing most commonly occurring vowels with systematic changes in stress patterns in the productions. Later the consonants within the bisyllabic utterances are varied while vowels are constant; progressing to varied consonants and vowels. The child then moves on to trisyllables which follow the same progression.

In the next phase of therapy, a sound is selected which was produced correctly in at least one phonetic context so that the appropriate sensory motor pattern may be stressed. At this point the clinician is to build progressively, relative to the correct context. McDonald notes that stimuli need not be meaningful as it is the movement sequence that is the focus. Following that phase, the next emphasizes transfer of the correct production across systematically varied contexts (1964, p. 146). Again the emphasis is on the construction of appropriate movement patterns to accomplish this goal all of which McDonald has carefully described in his text. McDonald's approach corresponds with the fourth level of the Kent and Minifie model in which transitions to and away from a target phoneme are computed.

Johnston, Goldberg, and Mathers' Coarticulation Therapy Approach. Another clinical approach for articulation remediation based on coarticulation principles is that developed by Johnston, Goldberg, and Mathers (1984). These writers stress the need for departure from previous therapy models which rely on acoustically based assumptions regarding articulation remediation, and the treatment of the phoneme as a static entity.

> Stated simply, coarticulation of adjacent sounds in the normal stream of speech means that they are temporally and spatially 'smeared'. Rather than maintaining the exact place, manner, voicing, and length characteristics of the sound in isolation, the coarticulated sound overlaps with its neighbors so that features of the neighboring sounds appear in the features of the sound undergoing coarticulation" (1984, p. 32).

These investigators in their review of pertinent literature on coarticulation emphasized that it is not only necessary to consider the production implications from previous research, but that coarticulation is necessary so that speech may be perceived as intelligible and natural (p. 32).

Johnston, Goldberg, and Mathers suggest the use of the McDonald Deep Test of Articulation and/or the Screening Deep Test of Articulation as the initial assessment technique for their approach. They feel that though

McDonald examines phonemes in several contexts, these contexts are constrained to those stimulus items which are used to elicit a combined two word response. Johnston, Goldberg and Mathers' second part of assessment is further testing of those phonemes found to be in error on the deep test. In order to produce an in-depth test of the integrity of the child's sound production system, they have developed an instrument that allows for the production of the target phoneme in all phonetic contexts. They developed the "Flip-a-Phone" which is composed of two sets of consonant sound cards and two sets of vowel sound cards. Each card set is held together by a metal ring that allows the examiner to select specific sounds so that as many as all four sets may be used together to provide a given sequence of graphemes. In this manner the examiner may construct CV, VC, CVC, VCV, CVCV, and VCVC sequences for both assessment and therapy purposes. Johnston et al. acknowledge that this program requires some form of visual letter recognition. A special form for recording contexts which are in error is used with the flip-a-phone instrument. The results of the McDonald and the Flip-a-Phone assessment are then used to design a therapy program.

The exclusively motor oriented nature of this approach is reflected in the authors' statement, "The aim of a coarticulation therapy program is, via systematic phonetic rehearsal, to increase neuromuscular integrity and thus facilitate the growth of control skills necessary for sound production/combination." (p. 43).

This therapy program consists of five levels and though based on the Kent and Minifie model, Johnston et al. note that the program does not "follow" the Kent and Minifie hierarchical model. Throughout all five levels the Flip-a-Phone instrument is used. The first level begins with the evaluation of coordination of respiration for appropriate initiation and duration of phonation. The program then proceeds to selection of target consonants and those vowels which have been described in the research literature as being facilitative of given consonants. The levels then proceed from CV and VC productions, progressively through level four which includes the four phoneme sequences of VCVC and CVCV. Variety, sequence and number of vowels and consonants are specified throughout the levels. The fifth and final level is concerned with carryover. It is at this level that meaningful words are first introduced at the end of a carrier phrase. Then the phonetic character of these words initially should correspond with one of the four phoneme sets of consonant and vowel combinations found in the fourth level. This level then continues on with specified phoneme sequences while incorporating frequently used English words. The tasks become more complex as the target consonants are presented in phrases, sentences, reading passages, tongue twisters, and spontaneous speech (p. 43-44). This approach also corresponds to the fourth level of Kent and Minifies' model.

Both McDonald's sensory-motor approach to articulation and the Johnston, Goldberg, and Mathers' coarticulation approach stress the importance of "movements" of the articulators which is consistent with the emphasis of both approaches on the physiological aspects of speech. Both proceed from levels of relative production simplicity toward progressively more complex utterances. McDonald advocates the selection of a sound for treatment that is correctly produced in at least one context, and the use of that context to reinforce the correct sensory motor pattern. Johnston, Goldberg, and Mathers do not incorporate this notion in their plan. McDonald clearly attempts to use consideration of consonants which when positioned in an immediately adjacent syllable abutting the target consonant result in correct productions by the child. In contrast, the description by Johnston et al. of their approach is such that the reader can only assume that these writers do not appear to consider abutting consonant contexts for inclusion in their therapy hierarchy. There are a number of differences in the syllable drill levels for both approaches in regard to consonant and vowel selection, arrangement of sequences, and the inclusion of "stress" as a factor in movement sequences. Neither approach appears to be concerned with articulator movements in meaningful utterances until after the child has experienced the opportunity to produce increasingly complex phonetic sequences so as to ensure that physiological capability for any possible speech production demand is adequate.

Both of these motor-based approaches appear to be limited in applicability for the very young misarticulating child. McDonald's (1964) approach would appear to be more suitable for older children, particularly in regard to his expectation for verbal description of "tactile sensations and feelings of movements" (p. 138). In fact, he refers to school age children in his discussion of the sensory-motor approach. Johnston, Goldberg, and Mathers' approach would also appear to be more suitable for the school age child as their approach requires visual letter recognition.

Descriptive Studies Relative To Traditional Treatment Approaches

Effects of context on [s] production. It is obvious from the preceding discussion that the effects of context on the accuracy of production of target sounds is an important variable within the theoretical framework. Several studies have investigated contextual effects upon [s] articulation adequacy.

Earlier descriptive studies of [s] misarticulators from kindergarten through sixth grade (Nelson, 1945; Hale, 1948) revealed that a majority of the [s] misarticulators studied produced [s] correctly in at least in one context. One study (Nelson, 1945) found that most of those children produced [s] correctly in cluster environments but not as singletons, while the other study (Hale, 1948) found the reverse. Snow (1963) provided a detailed analysis of normal children's correct and incorrect productions on a standard articulation test and suggested that phonetic context and the sound's position in the stimulus word could affect production accuracy. In the case of /s/, for example, Snow's findings suggested that [s] production in initial and medial word position was more difficult than in the final position.

Gallagher and Shriner (1975a; 1975b) examined the effects of syllable context on adequacy of [s] production in the spontaneous speech of three normal children, ranging in age from three years two months to three years ten months. These children exhibited inconsistent production of [s] and [z] and the investigators noted that there was considerable variation in [s,z] production ability among the three.

Spontaneous speech samples were obtained in the children's homes with their mothers present. All samples were recorded on audiotape with over eight sessions on each subject yielding approximately 2000 utterances per subject.

In both studies (1975a, 1975b) the investigators applied the theoretical model by Kozhevnikov and Chistovich (1965) who proposed the CnV syllable as the basic speech programming unit (where "CnV represents any number of consonants preceding a vowel and the syllable is, therefore, not lexically constrained." (p. 169). In Gallagher and Shriners' first analysis (1975a), samples were transcribed with regard to correct vs. incorrect [s] and [z] in CnV syllabic units. Pauses and silent intervals were scored as nulls and treated as vowels (p. 170). Distortions and omissions of the target sounds were not subjected to analysis, constituting approximately 5% of each child's sample. Error forms included in the analyses were substitutions for [s] and [z]. All perceptual judgments were made by one investigator.

The investigators noted large differences in error rates among the three subjects, though these were more pronounced with regard to [z] than to [s]. Comparisons were made between the proportions of lexically constrained vs. nonlexically constrained CnV sequences containing /s/ and /z/. Results indicated that /s/ occurred approximately 56% of the time in nonlexically constrained syllable sequences.

Comparison of proportions of syllables containing correct vs. incorrect [s] and [z] segments revealed that correctness of [s] or [z] was not affected by position of the targets relative to lexical boundaries (p. 173). However, their data indicated that "there is a greater chance of error when /s/ and /z/ occupy the C1 position within a syllable (C3C2C1V), the consonant immediately preceding a vowel, than when they precede another consonant, such as in the C2 or C3 position." (p. 172). Child II was an exception to this finding and his performance revealed a slight reverse trend (p. 172). Additionally, the investigators acknowledged differences in the degree of effects observed between /s/ and /z/, but maintained that the "major trends were the same for both." (p. 173).

Close inspection of their data table on the relative proportions of [s] or [z] productions in correct vs. incorrect samples by child and consonant position reveals that: Child I produced [s] with a frequency of .185 out of the total number of [s]'s in the correct sample in the C1 position and produced [s] with a frequency of .460 out of the total in the incorrect sample in C1 position; Child II (slight reverse trend) exhibited a frequency of .319 out of the total in the correct sample in the C1 position and a frequency of .259 in the incorrect sample in that position; and Child III for C1 position exhibited .345 in the correct [s] sample vs. a frequency of .389 in the incorrect sample. There is no question that Child I exhibited difficulty in producing [s] in C1 position and the investigators already noted the exception with Child II. The case with Child III, however, appears equivocal. The data for /z/ did indicate a consistency in the trend as they reported across all three children. The case for production accuracy of [s] in C1 position relative to the vowel does not appear clear.

Gallagher and Shriner interpreted their data to indicate that the "transition from C to V appears to be more difficult, or to place more constraints on the physiological mechanism than the C to C transition." (p. 174). In fact, going on the absolute face values of the percentages as presented in the data table (table IV, p. 173), only one of the three children (Child I) demonstrated a clear tendency to produce [s] correctly more often in C2 position. Of the two who didn't, Child II exhibited .555 correct and .707 incorrect and Child III exhibited .566 correct and .570 incorrect. These observations regarding [s] production in C1 and C2 positions, when taken together, do not appear to support the interpretation of the transition from C to V as necessarily "having greater chance for error" in regard to [s] production than when a consonant immediately precedes another consonant as in the C2 position (p. 172); nor do they clearly support the contention that the trends for /s/ and /z/ are the same (p. 173).

Overall, Gallagher and Shriner interpreted their data as being consistent with Perkell's (1969) physiological model of speech. The investigators observed that Perkell's model would have predicted the findings of a C to V transition being more difficult than a C to C transition. Gallagher and Shriner only looked at /s/ and /z/ and as previously mentioned their data on [s] production in the three subjects studied does not appear to support such an interpretation as clearly as their data on /z/ production in the same three subjects.

House (1981) in a critique of the Gallagher and Shriner study questioned whether the proposed principle of the C to V transition being easier than a C to C transition has any general properties. He asked whether such a principle would "...lead to the expectation, for example, that given a series of words such as (1) sore, (2) straw, and (3) store, that errors in [s] production decrease from (1) to (2) while errors in [t] production increase from (2) to (3) - the [s] going from a CV to a CC format, while the [t] format changes from CC to CV ?" (1981, p. 100).

The second analysis by Gallagher and Shriner (1975b) was performed on the spontaneous speech samples that were obtained and described in their earlier report (1975a). In this second analysis, however, they examined non-lexically constrained VCnV syllable units. They then were using both the CnV syllable considered to be the basic speech programming unit by Kozhevnikov and Chistovich (1965) as well as the unit suggested by Ohman (1966), the VCn (1975b, p. 625). Once again the focus was on the correct and incorrect productions of the [s] and [z] sounds.

Results of this analysis revealed that the "data concerning the possible relationship between preceding sounds either consonants or vowels, and the accuracy of [s] and [z] production proved to be negative." (p. 630). The identity of segments following [s] and [z] did appear to influence accuracy of production, though this coarticulation interaction was restricted to the consonantal portion of the syllable (p. 630). Gallagher and Shriner interpreted these findings as supportive of the proposed models of Kozhevnikov and Chistovich, and Ohman, "...in which speech segments are not regarded as discrete elements but as components of larger articulatory gestures. The production of a speech segment, therefore, would be influenced by motor sequencing constraints imposed by other segments comprising the unit." (p. 630).

In an analysis of consonant class effects on [s] and [z] production the investigators concluded that both manner and place of articulation of those segments following /s/ and /z/ affected accuracy of production; place, more so than manner. The investigators compared their results with earlier studies noting that this investigation confirmed earlier speculations posed by Spriestersbach and Curtis in their 1951 study regarding the effects of place of articulation on [s] and [z] but only in regard to consonants following /s/ and /z/. Gallagher and Shriner further noted that distinctive feature theory would have predicted that accuracy of [s] and [z] would have been better when followed by /θ/ or /ð/ then /t/ or /d/, due to having more features in common with the former. In the present study, however, the data revealed the reverse, which the investigators felt argued against the applicability of distinctive feature theory as a model of speech production. Overall, they felt their results were consistent with those models proposed by Kozhevnikov and Chistovich (1965) and Ohman (1966).

Mazza, Schuckers, and Daniloff (1979) examined the effects of segmental context upon the success of [s] production in ten children ranging in age from five years nine months to seven years two months (x age= six years five months). All ten subjects misarticulated [s] interdentally in all positions for singletons and clusters, as revealed by performance on the Goldman-Fristoe Test of Articulation (1969). Each subject repeated fifty-four sentences, forty-eight of which contained a single occurrence of [s] embedded interconsonantally in /C1sC2V/ contexts. In every sequence containing /s/, word boundaries occurred either immediately prior to /s/ or immediately following /s/. Each subject repeated the set of sentences which were presented in a randomized order each day for three days. Transcription was performed live as each subject produced the stimulus sentences.

Analysis of contexts in which [s] was successfully produced revealed a wide range of correct [s] productions in differing phonological contexts (p. 60) with 90% correct on [pska] at the upper bound and 3% correct on [nsni] representing the lower bound. Mazza et al. interpreted the results of this investigation to indicate that different segmental contexts did have differential effects on correct/incorrect productions of [s], which accounted for the childrens' inconsistencies in [s] misarticulations. The investigators considered their results as in agreement on this finding with earlier studies, citing Gallagher and Shriner (1975a, 1975b), Stephens and Daniloff (1977), and Hoffman, Schuckers, and Ratusnik (1977) (1979, p. 64). Optimal stridency was achieved when consonants adjacent to /s/ were not homorganic with [s], and were non-nasal. Contexts in which [s] was most often correctly produced were the following: [psk], [pst], [kst], and [psp]. Mazza et al. (1979, p. 62) also observed that their finding that the consonants preceding /s/ had a greater differential, facilitory effect than those following /s/ was at variance with the findings of Gallagher and Shriner (1975).

In a critical review of research on articulatory inconsistency, House (1981) observed that Mazza et al.

(1979) did not control for the variable of /s/ clusters when they formed the initial or final word boundary. In a reanalysis of their data and allowing for lexical boundaries, House (1981) argued that the context effects claimed by Mazza et al. should be attributed to the influence of relative difficulty of producing [s] in clusters depending on whether the cluster serves as the initial lexical boundary or the final boundary. Specifically, "...final /s/ is produced correctly with higher probability than initial /s/." (1981, p. 102). House, then disagreed with the conclusions of Mazza et al. on the specifics of their claims on contextual effects.

In another study conducted by Haynes, Haynes, and Jackson, (1982) the effects of phonetic context were once again examined in children who misarticulated [s]. This time however, linguistic complexity was also examined for its effect on misarticulation making this study the first to examine both variables in one design focusing on the same consonant. The questions addressed in the Haynes et al. study which are of interest here are those dealing with effects on [s] production resulting from specific phonetic contexts, particular phonemes, and position of phonemes relative to [s] in context.

The subjects in this investigation were nine children (five females, four males) with a mean age of 6.8 years (neither range nor age breakdown were given). All subjects misarticulated [s] and [z] interdentally in the initial, medial and final positions of words. None exhibited any other speech errors.

Haynes et al. used 48 sound-in-context sequences as stimuli. The sequences used in the present study were different from those in the Mazza et al. (1979) study but were created to conform to several constraints used in the earlier study (p. 289). Each of the stimulus items contained only one /s/ occurrence and no occurrence of /z/. In this study 16 noun phrases with /C1sC2/ sequences embedded formed the "simple" linguistic complexity level. In the /C1sC2/ sequences, consonants /k,t,n,p/ were permuted in the C1 and C2 positions (1982, p. 290) as was the case in Mazza et al. (1979).

The "complex" level of stimuli was composed of 32 sentences formed from the 16 noun phrases. Sixteen of the 32 sentences used the noun phrases as subject noun phrases such that each noun phrase initiated a sentence. The remaining sixteen sentences were formed with the noun phrases as object noun phrases which terminated each sentence. All of the sentences were simple sentences.

Their analyses revealed a significant phoneme context effect, which they felt generally supported the earlier findings of Mazza, Schuckers, and Daniloff, though the findings of the earlier study were specific to preceding consonants. Haynes et al. found that [p] was the most facilitory context, followed by [k,t], and [n]. Though both studies found the [psk] context to contain the highest percentage of correct [s] responses, the findings of the present study differed from those of Mazza et al. Haynes et al. did not find a position effect. This was contrary not only to the Mazza et al. findings on preceding consonant effect, but also to the findings of Gallagher and Shriner who found a following consonant effect (p. 295).

Weismer and Elbert (1982) conducted a study of the temporal characteristics of [s] productions in both misarticulating and normal children. This study will be more comprehensively reviewed in the next section on sensory motor differences in [s] misarticulators. However, there were findings from this study that are relevant to phonetic context effects that are pertinent to the present discussion. Only those aspects will be referred to here.

Weismer and Elbert compared measurements on duration of [s] when produced in vocalic vs. cluster (/s/-stop clusters) environments in four to six year old children. In the normal children there was greater variability in [s] duration in cluster environments then when /s/ occurred as a singleton. In the misarticulators this difference was considerably pronounced in that there were considerable reductions in durations of their [s] productions in clusters. They interpreted their findings as indicating that production of [s] in vocalic environments was temporally less difficult than in [s]-stop clusters. They felt that their results contradicted the assumptions expressed in the earlier study by Gallagher and Shriner (1975a).

All of the preceding studies just reviewed sampled speech over a very brief interval, yielding information relative to only that point in time. A longitudinal investigation of the development of [s] production was recently conducted by Stephens, Hoffman, and Daniloff (1986). Their subjects who were five years old at the beginning of the study were followed for three years during which time sampling of their speech production took place at regular intervals. In this study, the investigators examined the influence of particular error type on the development of [s] production. Specifically, they looked at three allophonic error forms of [s] as described in an earlier study by Daniloff, Wilcox, and Stephens (1980) (dentalized [s], lateralized [s], and bladed or retracted [s]). Additionally, Stephens et al. studied the effects of phonetic context for its effect on the development of [s] production.

The subject sample at the beginning of the study consisted of 53 [s] misarticulators (34 males, 19 females) who were five years old when the study was initiated. Subjects evidenced up to two additional phoneme errors as determined from their performance on standard picture articulation tests. At the beginning of the study, one experienced examiner categorized the subjects relative to their allophonic error form. In all, thirty-five subjects were categorized as dentalizers, twelve as retractors, and six as lateralizers. All of the subjects were considered to be producing fricative allophones for [s] (p. 254).

Speech samples on two sequential presentations of 34 stimulus sentences were obtained on an imitative basis from the subjects at eight fixed intervals across each school year, for three consecutive years.. These simple sentences provided for the sampling of /s/ in sixteen phonetic contexts in which [s] occurred prevocalically; contexts in which [s] was preceded by [p,t,k,n,r,l,č]; and contexts in which [s] was followed by [p,t,k,n,r,l,č].

Stephens et al. found a "strong effect of error allophone" after examining their three year totals (p. 251). Mastery was defined as exceeding 90% in correct productions. Nearly all of the retractors mastered [s] by the age of seven, while only half of the dentalizers and none of the lateralizers did so (p. 251).

Their findings on effects of phonetic context are of particular relevance to the present study. Graphs depicting group averages of percent correct for dentalizers and retractors relative to consonantal and vocalic contexts were presented and supported the conclusions of the investigators. With regard to phonetic context effects the authors concluded that phonetic context of [s] had little effect on [s] production development (p. 254). They noted that across or within subgroups there was no consonantal, vocalic or positional context that resulted in differentially influencing correct [s] production. They also reported as a part of their data analysis that there appeared to be little influence regarding the place of articulation of the contextual phones on /s/ development (p. 253). Stephens, Hoffman, and Daniloff felt that these results supported those of Deidrich and Bangert (1980) regarding the lack of context effects in general, though such effects could exist idiosyncratically. The authors also noted that the subjects in this group did not represent those who utilize phonological processes such as "stopping" and suggested that these individuals would fall in a different group.

In summary, a number of the studies reviewed reported evidence of context effects which affected the production accuracy of [s], though the nature of these effects varied with each study. The Gallagher and Shriner (1975a,b) studies involved three three-year old normal children in the process of acquiring /s/. Spontaneous samples were investigated relative to CnV and VCnV syllable structures that included /s/ in one of the consonant positions. These investigators concluded in the first study that when /s/ occurred in the C1 position of a C3C2C1V structure that it had a greater probability of being in error than in the C2 or C3 position. In the present review this particular finding was questioned. In their second study (1975b) Gallagher and Shriner concluded that only consonants following /s/ influenced its correct production. Mazza, Schuckers, and Daniloff (1979) studied five to seven year olds who exhibited interdentalized /s/ productions. Their subjects repeated stimulus sentences containing C1SC2V sequences. They reported context effects on [s] accuracy of production, but noted that preceding consonants had a greater effect on [s] production, in contrast with the effect of the following consonant as noted by Gallagher and Shriner. Haynes, Haynes, and Jackson (1982) investigated both phonetic context effects and linguistic complexity regarding [s] production in children with a mean age of 6.8 years who also misarticulated [s] (as well as [z]) interdentally. They used C1SC2 sequences in stimulus noun phrases as one level of difficulty, and then used the same noun phrases in sentences as subjects and then as objects as a more difficult level for production. Findings reported which are relevant to the present study include a specific phoneme effect /p, k/ without any position effect (i.e., preceding vs. following). Weismer and Elbert, (1982) studied 4 to 6 year old children who misarticulated [s] interdentally and who articulated normally, and they studied a comparison adult group in order to investigate temporal characteristics of [s]. They reported significant vowel and consonant context effects on duration of [s] in the misarticulating children. Stephens, Hoffman, and Daniloff (1986) conducted a longitudinal investigation on the development of [s] production in five year olds who exhibited fricative allophonic variations for [s]. They reported a strong effect of error allophone type on [s] production development and reported that phonetic context of [s] had little effect on [s] production development.

Direct comparisons across these studies are difficult due to differences in subject age, normal vs. misarticulating subjects, spontaneous vs. imitative stimuli, motor units vs. linguistic units, and experimental design. Additionally, there was considerable variation in the nature of the respective findings.

All of the studies reviewed in this section, however, involved children who either produced [s] correctly to some degree, or produced a fricative allophonic variation of [s] as a substitution for [s]. In all cases it could then be argued that these children demonstrated knowledge of /s/ as a meaningful contrast in their phonological systems and produced it accordingly. It would seem likely that whatever differences existed between the productions of these children compared to subsequent correct [s] productions would then suggest some form of production level difficulty. In other words, the individuals who demonstrated [s] misarticulations in the studies reviewed here could be described as having difficulty at approximately the third level or lower in the Kent and Minifie speech production model.

Studies of sensory-motor differences. McDonald (1964) suggested that functional misarticulation was due to "multiple-coexisting factors". Any one of these subtle deficits may have been insufficient to cause a child to misarticulate. However, the combination of a number of deficits in an individual child conspires to cause a problem. The first forty years of modern research into causes of children's misarticulations failed to reveal any dominant single structural-functional or psychological etiology (Winitz, 1969). More recent studies employing oral-sensory, oral-motor, and selected speech production tasks have suggested that particular speech sound errors may be related to specific patterns of deficit.

McNutt (1977) conducted a study to assess differences in specific sensory and motor abilities in [r] misarticulators, [s] misarticulators and children with normal articulation. He cited evidence from earlier studies which indicated that subgroups may exist among misarticulating children which might be distinguished on the basis of certain nonfunctional abilities in conjunction with their respective misarticulation patterns.

Subjects included 15 normal children, 15 [s] misarticulators, and 15 [r] misarticulators. Misarticulating subjects were required to exhibit only the defective [s] (though they allowed for defective [z] also) or [r] in conversational speech according to their respective group requirements. The requirements for the normals were that they exhibit no articulatory errors during conversational speech or formal testing, and have had no history of past therapy or disordered speech. The subjects mean ages by group were: normals, 13 years 11 months; [s] misarticulators, 13 years, 7 months; and [r] misarticulators, 14 years, 4 months. Ranges were given for each group which spanned approximately two and a half years each.

Measures included in the investigation of all subject's sensory and motor abilities were: two point discrimination on the lingual surface (cited Lass, Kotchek, and Deem, 1972); oral form discrimination (cited Ringel, Burk, and Scott, 1968; Ringel House, Burk, Dolinsky, and Scott, 1970; Sommers et al., 1972); and alternate motion rate (AMR) of the tongue (cited Darley, Aronson, and Brown, 1975; Winitz, 1969). The tasks were counterbalanced in order and sequence of presentation within each group.

Results of McNutt's investigation revealed that [s] misarticulators though performing essentially normally on two-point discrimination and oral form discrimination were deficient in oral AMR abilities. In contrast, the [r] misarticulators demonstrated deficiencies in all measures. McNutt suggested that such sensory or motor differences in children exhibiting a particular sound error might indicate non-functional differences, though such children would have been originally classified as "functional" misarticulators. Additionally, McNutt felt that his findings were consistent with findings of earlier studies involving [r], in which he cited Weinberg, Liss, and Hillis (1970) and [s] misarticulators, in which he cited Longegan (1974).

McNutt noted that his findings are limited to the older age group of misarticulators, but also observed that 13 and 14 year old children who are still misarticulating a particular phoneme may be significantly different from younger multiple misarticulators. Overall he felt that his findings supported the notion that children who exhibit difficulty with different specific error sounds may exhibit different sensory and motor abilities.

McNutt and Hamayan (1984) conducted a study on older misarticulating children to determine homogeneous subgroups. The investigators used a language model which emphasized receptive-central-expressive aspects. They felt that because these aspects have an interactive and additive effect, examination of multiple variables rather than a single variable was essential. They therefore used a multivariate approach in which they assessed psychoacoustic, psycholinguistic, and sensorimotor abilities. McNutt and Hamayan expressed the belief that children previously identified as functional misarticulators could be described in terms of profiles relative to performance on measures of these various ability areas.

Sixty children with a mean age of nine years eleven months served as experimental subjects. Each demonstrated at least one phoneme error during articulation testing. Thirty nine children, with a mean age of ten years two months served as controls. The control subjects demonstrated no articulation errors. Each child completed the entire assessment and additional information was obtained on each regarding handedness, sex, and parental occupation.

McNutt and Hamayan utilized a Q-technique of factor analysis which allows the investigator to determine clusters or groups of individuals who perform in a similar manner on the variables under analysis. They presented their resulting subgroups as preliminary groups noting that additional research using different classification approaches, different measures, and additional subjects is still needed.

Six factor groups resulted from the data obtained from thirty-one nonarticulatory measures on all sixty subjects. The investigators subdivided these six factor groups into two subgroups each, one subgroup with high factor loading scores and one with low factor loadings for each variable. McNutt and Hamayan interpreted each of these twelve subgroups to be relatively homogeneous with regard to the measures taken from their performance on all of the nonarticulatory variables (p. 58). The investigators also identified additional characteristics of each subgroup relative to the articulation and phonological process measures used.

Each of the twelve subgroups was described relative to nonarticulatory and articulatory measures, substitution rules and natural phonological process rules. As a result of their findings McNutt and Hamayan felt that older misarticulating children may be described as homogeneous relative to certain articulation and phonological process measures. They urged application of their procedures to younger misarticulating children in order to obtain developmental information relative to these subgroups.

Weismer and Elbert (1982) conducted a descriptive study on durational characteristics of [s] misarticulations in 4-6 year old children. They obtained acoustic data on both normal and misarticulated [s] productions in order to develop a reliable method in which to describe and compare such productions. In presenting their rationale, these investigators repeated an observation by Kent (1976) in which he noted that "timing" is a critical aspect of skilled motor performance. Weismer and Elbert related this observation to the repeated claims of prior studies that functional misarticulations often reveal considerable variation relative to normal speech productions. Weismer and Elbert suggested that such variability in speech production behavior could be due to deficient motor behavior (p. 277). The investigators hypothesized that if [s] misarticulations were in fact due to a deficiency in motor skill, the acoustic output of these misarticulations should reveal duration differences relative to the [s] productions in normally articulating peers and adults (p. 278). This study also provided information on phonetic context effects on [s] production.

Subjects selected for this study included three groups. There were seven adult subjects who exhibited normal speech, aged 22-35 years. There were fourteen children, aged 4 years 3 months to 6 years, seven of whom served as normals, and seven who served in the [s] misarticulation group. The children had to produce normal stop consonants on the Goldman Fristoe Test of Articulation (1969) and either had to correctly articulate or misarticulate all [s] sounds on the test; [s] misarticulations had to be [θ/s] substitutions as the investigators wanted to establish a homogeneous group. Weismer and Elbert noted that these misarticulations were not to be considered as speech problems requiring intervention as these children could have been in a normal developmental phase at the time of participation.

Speech samples were obtained on the subjects within one week of selection, over one to two sessions. The sample consisted of 45 nonsense sequences which included /s/ in various word positions and phonetic contexts. Additionally, the sample contained four occurrences of /θ/ as a fricative comparison phone. All sequences were preceded by a brief carrier phrase.

Results of the investigation were reported in considerable detail including graphs and data tables. Weismer and Elbert concluded that their findings were consistent with other types of speech production data in previous studies. Their results indicated that [s] misarticulating children demonstrate greater durational variability in their [s] productions, particularly in /s/-stop clusters than normally articulating peers. Likewise, the normally articulating children demonstrated greater duration variability than adults in [s] productions. Weismer and Elbert commented on previous studies (Smith, 1978; Kent and Forner, 1980) which had found the same duration differences between normal children and adults, and in those studies the investigators discussed the use of segment duration magnitudes as an index of speech motor control. Weismer and Elbert hypothesized that if such differences in the misarticulators were true indicators of reduced motor skills that similar differences should be observed between normals and these misarticulators on sounds that both articulate correctly. The investigators noted that in comparing the correct /ɵ/ productions in both groups, average intrasubject standard deviations were 44 and 27 msec for the misarticulating and normal children, respectively. Additionally, similar comparisons on intervocalic [s] were 43 and 25 msec, respectively.

Results of performance in singletons vs. clusters between the two groups of children were pertinent to both motor control interpretations and context effects as mentioned previously. Weismer and Elbert noted that in normals there was a slight increase in relative variability in clustered /s/ data than exhibited in the singleton /s/ data, but in the misarticulating children the difference was pronounced. In the misarticulating children, [s] duration in clusters was considerably reduced, and the authors felt that this loss of precision could indicate motor control difficulties. These investigators in their discussion of findings described motor control aspects of [s] in a vocalic context as less difficult than in [s]-stop clusters. They noted that this description contradicts the assumptions expressed in the earlier work of Gallagher and Shriner (1975) and suggested that the earlier study's findings could have been due more to listener perception in judging the sounds than in the speakers' productions of the sounds. Weismer and Elbert stated that physiological assumptions based on perceptual judgment need further exploration before such assumptions could be justified.

Treatment Studies Within The Motor Sensory Paradigm

A number of studies have evaluated the effects of treatment aimed at teaching correct production of speech sounds in syllabic production. In this section, studies showing effects of syllabic training on production are reviewed.

Powell and McReynolds (1969) conducted a study to investigate generalization effects of a training program which contained several phases. The training program consisted of four basic phases; isolation; initial position training in nonsense syllables; medial position training in nonsense syllables and final position training in nonsense syllables. Three additional phases, one for each of the same positions in words, were incorporated if a subject failed to generalize completely following the first four phases.

The investigators were interested in the following: whether [s] after training in isolation and nonsense syllables would generalize to previously misarticulated words; whether [s] after being trained in a particular position in a nonsense syllable would generalize to the same or different positions in words; and would there be changes in the number of correct articulations on the test probes as the subject progressed through the program. Similar questions were of concern on the three additional word level phases.

Four children ranging in age from 4 years 9 months to 6 years 10 months served as subjects. The subjects were selected on the basis of a score of less than 39 correct on the Templin Darley Nondiagnostic Screening Test; the absence of any correct responses on a twelve item pretest composed of meaningful words containing /s/ in all word positions which was administered five times over two days; and the inability to imitate the [s] sound.

Stimuli consisted of both verbal and visual stimuli. In the first four phases, verbal stimuli were [s], [sa], [asa], and [as]. In each phase a geometric form was paired with the stimulus for that phase, so that one of the forms was labelled [s], another [sa], and so on until all stimuli were so paired. In training sessions a different set of visual stimuli were used from those used to test generalization. The picture cards for word level training pictured items with names containing /s/ in the different positions and were presented in the same way as those at the syllable level.

During training the child progressed through sequential criterion referenced steps from verbal imitation to responding to the given stimulus card. Generalization probes for untrained contexts were administered at the completion of each phase.

Results revealed that two of the subjects demonstrated generalization to all of the probes by the end of the nonsense syllable training and of these two, one generalized without going through all of the nonsense phases. Both of these two were terminated from the program at the end of the nonsense syllable training.

Of the two remaining subjects, one generalized to all of the test probes at the completion of the entire program, including all word phases. The last subject had not generalized completely by the end of the program.

The investigators concluded that though the degree of generalization varied on an individual basis, "training a correct [s] in nonsense syllables will result in a correct [s] in other untrained contexts." (p. 643). This generalization extended to untrained familiar words. Powell and McReynolds refrained from drawing any direct conclusions based on the generalization performance by the two who had to complete the word level training. They did note that the added improvement by the two with the additional phases resulted in only limited improvement beyond that initially gained at the nonsense syllable level.

Another area of interest addressed by this study was that of the effects of training a sound relative to its position (initial, medial, final) in nonsense syllables and words. The investigators pooled the data and compared generalization for each position in the word probes at completion of each position phase in the syllable training. They reported that "...the position of /s/ had no influence on the position to which generalization occurred in a training program in which the positions were trained progressively. When the children generalized, they generalized to all positions regardless of the position that was being trained." (p. 639). Considerable variation by subject was revealed in terms of generalization patterns over time. The investigators reported similar results at the word level of training for those two who completed that part of the program.

As a final conclusion, Powell and McReynolds noted, "The data from this study indicate that the generalizations obtained were not a function of the order in which training was presented. Generalization from nonsense syllables to words, generalization to all three positions of the phoneme in a word, and an increase in generalization can not be attributed to the specific initial, final, medial training program." (p. 644). They suggested that as a result of the indications of variability in the acquisition of generalization and lack of retention of generalization that was revealed, the use of a repeated test procedure may enhance efficiency of training (p. 644).

McReynolds (1972) conducted an articulation training study using four [s] misarticulators who ranged in age from 6 years 1 month to 8 years 3 months. The study was conducted to determine the nature of any generalization that might occur following training at particular levels and on certain articulation forms in an articulation training program. A systematic check for generalization was conducted at the end of each phase of the training program so that any generalization that occurred could be described.

Baseline testing was performed by presenting picture cards depicting twelve familiar words containing /s/ (four words with /s/ in each position; initial, medial, final). The twelve pictures were presented to each subject at three separate times to obtain baseline information. All subjects consistently misarticulated [s]. These twelve pictures were used as generalization probes at pre-determined criterion points during each phase.

The training program consisted of four phases, training the sound in isolation, in initial position in nonsense syllables, in medial position in nonsense syllables, and in final position in nonsense syllables. Stimuli were verbal models provided by the examiner for the subject to imitate until the final training step of each nonsense phase. At that point, visual stimuli were used to elicit a spontaneous response. These stimuli were nonsense figures which had been labelled [s], [sa], [as] and [asa]. The appropriate figure for a particular phase was then presented for the child to name.

One generalization pattern that resulted from the training program indicated that no subject demonstrated generalization to word level productions at any time during the training of the imitation of isolated [s]. Generalization to word productions did not occur until the children were required to monitor their productions of the syllable [sa]. This was accomplished by requiring the child to produce three consecutive correct responses in order to receive a reinforcer rather than providing immediate feedback to the subject as to the correctness of the response.

Elbert and McReynolds (1978) investigated the role of context in misarticulating children's generalization of [s]. Five subjects (three boys and two girls) ranging in age from 5 five years 6 months to 6 years 4 months, participated in the study. To participate, each subject had to exhibit [s] and [r] errors on the Goldman Fristoe Spontaneous Articulation Test (1969), the McDonald Deep Test of Articulation (1964) and the Elbert, Shelton, and Arndt (1967) sound production task for [s] and [r]. All children were described as functional misarticulators, and all demonstrated interdentalized [s] or absence of [s] in some contexts. In addition to the above criteria, each subject had to demonstrate a baseline performance of less than 10% correct on each target sound on three baseline sampling dates on a sixty item probe of [s] and [r] (thirty seven items included /s/). Elbert and McReynolds considered the subjects to be in effect "nonstimulable" as they produced essentially no correct imitative responses.

This investigation utilized training syllables ([sʌ], [ʌsʌ], [ʌs]; and [θʌ], [ʌθʌ], [ʌθ]); and a 60 item generalization probe. An ABAB reversal design was used with /s/ being trained first in [sʌ], then [ʌsʌ], and then [ʌs]. Generalization probe items were untrained nonsense syllables and real words used during baseline and at every session (p. 139). The probe instrument allowed for sampling of contextual effects in six syllable categories: CV, VCV, VC, CCV, VCC, and VCCV.

Elbert and McReynolds reported that minimal syllable training resulted in generalization across positions, different vowel-consonant combinations, clusters, and both imitated and spontaneous items. The investigators did not find any strong data to support the notion of facilitative contexts as having a role in generalization. They did, however, find that the variable of stimulability, referred to as the ability to imitate CV syllables, (where C is /s/) did contribute to generalization. This particular syllable structure would correspond to the syllable level phase in

McReynolds' (1972) study in which generalization was found to occur following training on syllables with /s/ in the initial position, and which required the use of self monitoring. It also corresponds with the same level in the Powell and McReynolds (1969) study and the results in the present study are consistent at that level with those of the earlier study.

Another factor affecting generalization that was mentioned by Elbert and McReynolds was that of the amount of training required prior to generalization occurring. Finally, Elbert and McReynolds suggested that the error pattern the child brings to treatment, for example marking the presence of the sound compared to not marking it in some way, may also influence generalization.

Direct comparisons among the treatment studies reviewed in this section are difficult due to inherent differences in subject samples, design, and methods. However, several interesting findings emerge despite these differences. Findings regarding generalization following production at the syllable level were consistent across all three studies reviewed. These findings indicated that generalization occurred to untrained words following training on nonsense syllables in all three studies. In the two studies which included training on the sound in isolation, (Powell and McReynolds, 1969; McReynolds, 1972) neither revealed any generalization occurring at completion of that level prior to syllable level work. Further, two of the studies (Powell and McReynolds, 1969; and Elbert and McReynolds, 1978) found that generalization occurred across word positions after training on syllables with the target sound in initial position only, suggesting that specific training on target sounds according to word position may not be a necessary training step in all cases. The findings of Elbert and McReynolds (1978) also suggest that minimal syllable training resulted in generalization across vowel-consonant combinations, clusters, and in imitative and spontaneous responses.

Phonological Approaches

Recent discussions of normal speech sound production development have highlighted the child's cognitive organization of the sound system. Macken and Ferguson (1983) reviewed developmental data from normal children and proposed a two stage learning process. In the first stage children discover that sound can be used to represent meaning. At this stage they tend to produce particular speech sounds which are in some sense physiologically easier to produce. For example, stop consonants are almost always utilized in meaningful utterances before fricatives. Children use these sounds and relatively simple syllabic structures to represent adult words. However, there are differences in the sounds and syllable structures used by individual children, so even this first stage does not simply reflect motoric maturation of the speech production system. Furthermore, children appear to attempt adult words which fit their established patterns and avoid those which do not. Thus, the first stage of discovery is viewed as one of trial and error attempts on the part of the child to produce adult words. By chance, each child will successfully produce somewhat different word shapes. The child then uses these learned word shapes to select and organize future development.

In the second stage, the child forms hypotheses about the structure of the phonology of the parent language. Evidence for this active cognitive processing comes from demonstrations of regression in phonetic productions. Regression is seen when a child's production of a word is initially acceptable to an adult and later becomes less adult like when the child starts to use a general strategy. For example, Leopold (1947) described the following example of regression. A child at age 10 months produced the word pretty as [prItI]. However, her production of this word changed to [bIdI] at age 11 months. It is apparent that she was phonetically capable of producing the [pr] cluster. The change to a form less like the adult model coincided with her systematic use of cluster reduction and prevocalic voicing of consonants in other words. Thus, this child appears to have initially happened upon a relatively good production of a complex phonetic sequence, which she later altered by phonological rule.

In this section a model of the components of phonological knowledge which a child must figure out cognitively is presented. This is followed by a discussion of basic treatment strategies by which speech-language pathologists have attempted to help children develop appropriate phonological knowledge. Thirdly, studies showing that childrens' misarticulations can be described via phonological rules are reviewed. Finally, evidence from treatment studies is cited to show how effective these strategies are.

Model of Phonological Knowledge

Dinnsen (1984) has suggested a model for developing an empirically based description of the child's underlying representations. The model used in conjunction with information from the individual's speech samples may be used to determine how the child organizes his own phonological system. In such an approach, Dinnsen is advocating a position contrary to the more traditionally held view that the child's underlying phonological system is the same as that of those adults in his environment. Dinnsen maintains that "The fundamental distinguishing factor among functionally misarticulating children would be the character of their underlying representations." (1984, p. 14). He has observed that though some children may demonstrate evidence of underlying representations which are the same as the ambient community it is not so for all. His approach therefore presents a departure from a number of commercially available systems which do adhere to the a priori assumptions that the child shares the same underlying representations of the adult community (Ingram, 1976; Weiner, 1979; Hodson, 1980).

Dinnsen's model consists of several levels as illustrated in Figure 2.

INVENTORY RESTRAINTS

LEXICON (underlying representations)

SEQUENCING CONSTRAINTS

NEUTRALIZATION RULES

ALLOPHONIC RULES

Figure 2. Dinnsen's Model of Phonological Knowledge

As can be seen in the schematic, the first two levels include the phonotactic consisting of "inventory constraints" and "sequencing constraints". The level of "inventory constraints" is concerned with the child's phonemic inventory as determined from his phonetic output. This level may differ from other phonological models as Dinnsen does not make a priori assumptions regarding the child's phonemic inventory. This is important as in the case of what is frequently described as the process of stopping for continuants. When the clinician notes that the child doesn't exhibit continuants, but uses stops where the continuants occur, the traditional phonological view would be that the child is substituting the stops for the continuants. This is in keeping with the assumption that the child "knows" or has the same phoneme inventory of the ambient community. In the absence of any continuants, Dinnsen would claim that there could be an inventory constraint here in that the child may not actually have continuants in his inventory. Therefore there is no need to say that he is "substituting" anything. In order for him to substitute one contrast for another, he would first have to be aware of the contrast that he is not using as a meaningful one. But unless there is any evidence of that knowledge in the child's speech output according to Dinnsen's approach, there is no basis for the assumption that the child does in fact have knowledge of the meaning of such a contrast.

Likewise the level Dinnsen refers to as "sequencing constraints" would govern the allowable sequences that the child may use in combining phonemes for phonetic output. In the case of what is commonly referred to as the phonological process of cluster reduction, the child reduces a consonant cluster to one consonant. If the child exhibits continuants, but never exhibits them in clusters, this may be due to the fact that he doesn't know that such sequences are allowable, rather than a process of reduction for simplification purposes.

The Lexicon in which the underlying representations are specified is directly dependent on the phonotactic constraints, which as noted earlier function as a filter. In Dinnsen's description of the underlying representations he notes that they are composed of the "unpredictable properties" of the sounds and words contained (1984, p. 7).

> "Unpredictable" means those properties of a sound or word that are idiosyncratic, must be learned language specifically, and/or do not follow from any rules. For example, the underlying representation of the word "pig" in English is comprised of one morpheme meaning "swine" represented phonologically as /pIg/...It is totally unpredictable, for example that the initial segment of this word is bilabial, is a stop, and is voiceless. All this information must be learned in association with the particular morpheme meaning "swine".

Once the unpredictable properties are specified for a given lexical item, and phonological context is known, the neutralization and allophonic rules apply to the underlying representation to modify it accordingly. Dinnsen used the English plural morpheme to illustrate this point. He referred to the claim that there need only be one underlying representation for the plural morpheme. For example, if the underlying plural is /-z/, then depending on the noun stem, the phonetic realization, accomplished as a result of the operation of allophonic rules, may take one of three forms; [-z], [-s], or [-əz] (p. 8). In the case of neutralization rules, phonemic contrasts may be obliterated or merged depending on the phonological contexts, as in the case of devoicing of word final voiced ostruents (p. 9). The example here was an underlying representation /dʌg/ that was phonetically realized as [dʌk] due to the application of a neutralization rule.

Therefore, based on the underlying representations, which are based on inventory and sequencing constraints, the neutralization and allophonic rules are applied and result in the final phonetic realization. It is the description of these underlying representations from empirically obtained data that Dinnsen focuses on as central to an appropriate analysis of the child's phonological system.

Treatment Approaches

Phonologically based treatment strategies are often viewed under a broader linguistically based perspective in which the clinician is encouraged to consider variables such as semantic, pragmatic, and syntactic aspects as well as phonological aspects. This is a departure from the more traditional orientation in which speech has been approached more as a motor end product rather than considering its higher level cognitive aspects. As phonological approaches appeal to higher order systems, they include emphasis on the individual's knowledge of the linguistic system, its interaction with and the rules involved in the child's phonological system specifically, and how these variables may contribute to the production errors observed in the child's speech. Phonological strategies attempt to address what the child knows about his language's sound system, his "underlying representations" and his rules for deciding when to use which phonemes, and which features are included in which phonemes. This necessarily involves the child's awareness of meaningful phonemic contrasts which are important for him to know and use systematically in his particular linguistic environment. Such contrasts are exemplified in the phonologically based notions of "distinctive features" and "phonological processes". A given phoneme may be contrasted with any other on the basis of those articulatory/acoustic aspects which characterize it as unique from any other phoneme in a given phonological system. These characteristics are referred to as distinctive features. The term "phonological processes" generally refers to a systematic simplification strategy that is used when an individual attempts to produce an utterance, usually referred to as the "adult" form or target. Such a simplification results in a form that differs from that of the intended form, by phonetically reducing or altering it. The resulting phonetic realization then fails to produce an intended phonemic contrast and thereby reduces intelligibility. Some investigators describe phonological processes as having psychological reality and as a means to explain speech error patterns. Others prefer to use phonological processes only as a systematic method for describing articulation error patterns without making such assumptions (Stoel-Gammon and Dunn, 1985).

Treatment approaches which emphasize distinctive features and phonological processes as descriptive devices are "pattern based" approaches. That is, they maintain that correction of several errors by correcting the operation of a process or a faulty feature rule that appears to account for the errors in question is a more efficient method than attempting to correct the individual phoneme production problem in a sound-by-sound fashion.

A distinctive feature approach capitalizes on the acoustic or articulatory features that may appropriately explain a given error pattern noted across several phonemes which share a common feature; the feature classes used to describe the patterns may differ according to the particular descriptive system chosen (Jakobson, Fant, and Halle, 1963; Chomsky and Halle, 1968; Ladefoged, 1971; Stoel-Gammon and Dunn, 1985), since no single system has been accepted as containing the "most appropriate set" of universal features. A distinctive feature contrast uses a binary "plus"-"minus" system in which a given phoneme is considered relative to the presence or absence of a given target feature such as "voicing". The phoneme /d/ in English is phonetically realized as "voiced" or "plus voice", whereas it's cognate the phoneme /t/ is phonetically realized as "voiceless" or "minus voice".

In distinctive feature approaches, several phonemes containing a given feature may be used to teach the presence of the feature and are contrasted with phonemes marked by the absence of the feature. The key notion in this type of approach is that the individual develop an awareness of the feature, its contrastive significance, and its appropriate application. Approaches may use single phones, syllables and words to enable the individual to establish the contrast. When using single phones to contrast a given feature a pair is chosen so that one contains the feature while the other is lacking it. For example, to teach "voicing", [p] might be contrasted with [b]. These two productions differ only in the feature "voice". When using syllables and words, the stimuli are constructed so that they too only differ phonetically in the feature being taught; for example, again using "voice", the word [pIt] could be contrasted with [bIt]. This type of contrast is considered to be a minimal phonetic contrast; for this reason, this method of using such syllable or word pairs is referred to as "minimal pairs".

Phonological process approaches provide for analysis and treatment of articulation errors based on the identification of apparent simplification strategies which may be used to describe consistent error patterns exhibited in some children's speech. For example, a child who consistently produces a word like dog as [da] might be said to demonstrate the process of "final consonant deletion", in which case it is presumed that in attempting to produce the adult target the child deleted the final consonant. Likewise, a child who says [tu] for [su] would be said to demonstrate "stopping for continuancy" or "stopping", in which case he substitutes a stop for a continuant in attempting to produce the adult target. Such processes are considered to be developmental in nature in that if a child is still exhibiting them past a certain period, than the goal of treatment for such a problem would be the elimination of those processes still operating. There are several phonological process systems available to clinicians (Ingram, 1976; Weiner, 1979; Shriberg and Kwiatkowski, 1980; and Hodson and Paden, 1983) each stressing different numbers and types of processes. As with distinctive feature systems, there is no universally accepted single system, and at issue still is which and how many processes should be described, as well as agreement on definition and degree of occurrence necessary for classification as a process.

Nevertheless, a common feature to both distinctive feature and phonological process approaches is that of the often implicit assumption that the child's knowledge of his phonological system is essentially equivalent to the that of the adults from the same linguistic community. That is, the child's underlying representations are considered to be the same as those of the adults in his environment. Because of this assumption, the two approaches view errors as substitutions, deletions, (distinctive features, phonological processes) or additions (phonological processes). In other words the child's errors are viewed relative to what is assumed to be his adult knowledge of the phonological system. This assumption represents one of two major positions on the subject as described by Maxwell (1984) and as she noted is subscribed to by a number of investigators Smith (1973), Ingram (1976), Shriberg and Kwiatkowski (1979) and Weiner (1979). The second position acknowledge's that the child's underlying representation's would not necessarily be equivalent to those of the adults in his community, and could very well be idiosyncratic to a given child. Dinnsen's model allows for description of the child's underlying representations based on his own productive knowledge, as determined by examination of speech samples. Because of the empirical basis for such description, the investigator is not bound to reference only to the adult system and therefore does not automatically invoke processes or assumed knowledge as a basis for mistakes.

Presently, another characteristic of phonological treatment approaches that sets them apart from some forms of the traditional methods is that of the use of meaningful situations in the therapy process. As a fundamental part of an orientation that is more cognitively oriented than some of the more behaviorally oriented traditional approaches, such elements as situational context and pragmatics, semantics, morphology, and syntax may be considered in phonological assessment and remediation. As a result, the clinical situation in such cases encourages a more naturalistic communicative exchange, or interaction, with both child and clinician contributing to the form of the exchange as the vehicle for change, rather than an artificially constructed rote drill that would appeal more to motor skills practice. In so doing, the practitioner allows the child to discover the contrast between [pIt] and [bIt] by realizing that a certain picture or object was requested that has only one correct name. In order to be able to make the correct choice in a given request the child must demonstrate that he perceived the difference, and later must ask for it accordingly. By so doing he demonstrates that he not only knows the contrast, but can apply it productively. Such a situation can capitalize on the child's natural tendency toward interactive play as an inherent motivating factor to engage in communicative behavior, albeit directed toward a certain goal. Because of a more natural and conversational atmosphere, it would be hoped that the child internalizes his developing knowledge of the contrasts he learns. Generalization to untrained words in his own repertoire may be used as an indicator for such internalization of his new knowledge. Obviously, such a learning context differs markedly from those in which clinicians decide upon a pre-determined response set, whether they are items within the child's productive repertoire or not; a reinforcement schedule; and the reinforcers themselves. In other words, in the former case the approach is tailored to and by the child, while in the latter, the child is asked to fit the approach.

In recent years a number of studies have focused on ways to describe error patterns in children's speech and the effects of treatment designed to remediate these error patterns. A review of studies pertinent to these two topics follows.

Descriptive Studies Showing Error Patterns

McReynolds and Elbert (1981) conducted a study focusing on the use of "phonological processes" as a descriptive term for speech error patterns, and whether or not the use of such analyses justified relabelling functional misarticulators as "phonologically disordered". In this descriptive study the investigators examined the speech of thirteen subjects relative to the set of phonological processes described by Ingram (1976). The investigators' concern was that the label of "phonological process" was only a renaming of the same error patterns which have been previously described in different terms. Further, they felt that if the description was to be appropriately applied , then criteria needed to be used when applying such a term to demonstrate its validity and efficacy over previous methods. McReynolds and Elbert analyzed the same set of speech samples twice with the same set of phonological processes. One set of descriptions however, used quantitative criteria which had to be satisfied prior to labelling an error pattern as a phonological process.

In the other analytic method using the same method without the quantitative criteria, all that was required was that the error pattern occur a single time. McReynolds and Elbert noted that in order to provide empirical evidence for the presence of a particular process, the process should occur with some established degree of frequency rather than just once. The investigators also noted that for the quantitative criteria to be appropriately applied, opportunity for occurrence also had to be considered.

Thirteen children ranging in age from 3 years 7 months to 13 years served as subjects. The subjects had been referred to speech clinics/programs for functional articulation disorders of varying severity. Standardized articulation tests were administered to each (Goldman-Fristoe, 1969; Templin-Darley, 1969) and the investigators provided a breakdown of the number of errors each subject exhibited.

The investigators obtained spontaneous speech samples utilizing various methods including pictures that the children were asked to describe. A variety of grammatical forms was obtained on each. All samples were taped and transcriptions were made from listening to the recordings. Each word of each sample was analyzed relative to each process. These then were analyzed both by the quantitative criteria approach and the non-quantitative approach.

In order to qualify as a process in the

non-quantitative approach, an error pattern fitting a process description only had to appear one time to qualify as a process occurrence. In the quantitative criteria approach, the requirements to be labelled as a process were: 1) an error had to have at least four opportunities to occur and, 2) at least 20% of the items in which a process could occur had to be affected.

The results of each analysis were provided by both subject and process. Data was presented relative to presence or absence of a process occurrence with regard to the analysis used. Lack of opportunity was also indicated for each process by subject for each analysis form. Totals were calculated for each process relative to the number of subjects in that analysis form who demonstrated the presence of a process, such that the range for totals was 0-13. Totals were also calculated for the number of processes each individual subject exhibited under each analytic approach. When compared to the results of the non-quantitative approach, use of the quantitative approach resulted in a reduction of greater than 50% in the number of total processes exhibited across all subjects and the elimination of eight processes altogether. McReynolds and Elbert questioned the notion of "commonly occurring" processes due to a lack of any standards for supporting such a notion. They suggested that if a process were to be considered "general" in nature, it should have occurred in all thirteen subjects. With quantitative criteria a maximum of nine subjects were found to exhibit any single process, compared to three processes being exhibited by all thirteen subjects in the non-quantitative approach.

McReynonds and Elbert suggested that if both qualitative and quantitative criteria were applied to childrens' misarticulations, a significant decrease in children considered to be phonologically disordered would result. They commented on the implications of the need for better defining the notion of "phonological disorders" relative to professional accountability.

Hodson and Paden (1981) conducted a descriptive study on intelligible and unintelligible children to determine whether there were phonological processes which were characteristic of each group. The investigators defined phonological processes as "...phonetic/phonemic changes in speech that occur regularly for classes of sounds or sound position, not just for individual phonemes...The concern here is not with the child's underlying awareness of the alteration of the adult form, but rather with identifying surface patterns for remediation purposes." (p. 369). Their rationale for undertaking the study stemmed in part from the emphasis for remediation of communication problems in pre-school populations whereas in prior years remediation was delayed until the child was in school.

Two groups of children served as subjects for this investigation. Sixty essentially normal and intelligible children between the ages of 4 and 5 years served as subjects for the normal group. This group was composed of 30 males and 30 females all of whom attended private preschools, and selection criteria were described for this group. The sixty children comprising the unintelligible group were not described relative to any selection criteria other than that they were considered to be unintelligible and were between 3 and 8 years of age.

The analytic method used to determine the phonological processes exhibited by the two groups was Hodson's (1980) The Assessment of Phonological Processes which required the subjects to name 55 common items. The test items included "all American English consonants as singletons both prevocalically and postvocalically (except for /w/, /j/, and /h/, that of course are prevocalic in all instances) and 31 common pre and postvocalic consonant clusters. (1981, p. 370). This instrument utilizes 40 phonological patterns for scoring utterances. In the children demonstrating unintelligible speech, Hodson and Paden reported that all sixty subjects demonstrated the following five processes: cluster reduction, stridency deletion, stopping, liquid deviations, and assimilation. The investigators noted that all of the above except liquid deviations markedly affected intelligibility. Of particular interest to the present study, was that in the process of cluster reduction, the /s/ was the consonant most often omitted. This was the case with the 7 & 8 year olds as well even if they produced [s] singleton in the word initial position (p. 370). Stops were generally retained.

The investigators reported several phonological processes that were demonstrated in varying degrees by the intelligible children whose articulation performance was characterized as closely approximating the speech of the adults. It was noted that the processes evidenced in these childrens' speech did not markedly affect intelligibility. The processes in order of descending frequency were: devoicing of word-final obstruents; production of anterior strident phonemes to replace the non-strident interdentals; liquid deviations; tongue protrusions; depalatalization; assimilation, and metathesis.

Particular points of contrast between the two groups that were mentioned by the investigators included reference to the fact that cluster reduction, stridency deletion, and stopping, which were exhibited by all of the unintelligible subjects, occurred in fewer than five of the intelligible four year olds' utterances. Hodson and Paden noted that as a group, the unintelligible subjects exhibited a "group of processes" which differentiated them from the intelligible four year olds who only shared one process as a group, and one that didn't appreciably affect intelligibility.

A final conclusion reached by Hodson and Paden was that "...there are specific patterns or strategies which can be predicted in unintelligible speech, and that they differ from those in the speech of normally developing four-year-old children not only in the numbers of inappropriate patterns, but in the kinds that are utilized." (p. 373). No explanation was offered as to why there were selection criteria for the intelligible children who served as subjects while there were none specified for the unintelligible children. The single factor that appeared consistent among the unintelligible group was their unintelligibility. This characteristic of unintelligibility, was determined for each child apparently by one investigator and though the term was somewhat operationally defined, no information substantiating this diagnosis was offered relative to specific test and evaluation results on any of the individual subjects, or even the group. Because so little descriptive information was available on the unintelligible subjects, the reader is unable to verify the conclusion of the investigators. Questions as to whether or not the "unintelligible" subjects were in fact "unintelligible" is a primary issue. Secondary to that would be questions regarding other differences between the subject groups, and within the "unintelligible" group.

Singh, Hayden, and Toombs (1981) conducted a large sample descriptive study investigating the application of distinctive feature analysis in misarticulating children. The subjects for this study were 1077 children ranging in age from 2 to above 14 years of age who were receiving speech services in various settings within one city. Though all subjects had articulation problems, they were subdivided into diagnostic categories for the purpose of determining descriptive profiles relative to each group. The categories included: articulation delayed; language delayed; mentally retarded; hearing impaired; and cleft palate children. There were twice as many males as females in the total group. This report referred to children ranging in age from 3 to 8 years in these categories, and results were presented relative to percent correct features by age group with number per age group provided. Subjects were referred in by school speech pathologists who also provided articulation test information on each subject. Articulation information consisted of broad transcriptions of error phonemes by word position. The articulation information was then analyzed relative to the Singh and Singh (1976) distinctive feature system (which includes voicing, nasality, continuancy, sibilancy, front, sonorancy, and labiality) with the aid of a computer program. Only sound omissions and substitution error types were analyzed. For substitution errors both target and error forms were compared and error features were tabulated. (For omissions, errors were ascribed to all seven features (p. 175).) Errors were computed by feature in percentages and plotted (p. 175).

A distinctive feature hierarchy resulted from the analyses of speech samples from the total group of 1077 subjects. The investigators found that the hierarchy that resulted in their study was consistent with previous research findings and linguistic theory regarding production complexity. Features were ranked from "strongest" to "weakest" as follows: nasality, sonorancy, voicing, labiality, sibilancy, front/back, and continuancy. The articulation patterns exhibited by the whole subject sample were consistent with English phonological rules, and error patterns reflected normal phonological development patterns. In other words error patterns in the subjects were similar to what would be expected in normal development but in younger children. The diagnostic subgroup's speech productions were analyzed relative to the hierarchy established for the entire group. Differences were exhibited in some of the subgroup's performance relative to the established hierarchy which the investigators attributed to the special characteristics of that diagnostic category. For example, the articulation subgroup generally followed the established hierarchy more closely than the language disordered group, while the cleft palate group exhibited a markedly different trend from the sample group as a whole.

The performance of the articulation subgroup is of particular interest in the present study. Performance in the initial position was found to be superior to both medial and final (p. 176). Results revealed that age was significant across all features, and that three and four year olds performed significantly lower than all the other age groups, while five year olds differed significantly from 6 and 7 year olds in front/back and continuancy.

Treatment Studies

Stopping. Weiner (1981) conducted a treatment study designed to reduce the frequency of occurrence of several phonological processes in misarticulating children through the application of a meaningful minimal contrast approach. Weiner adopted this method as he felt it was conceptual in nature, rather than motoric, and that it was theoretically consistent with the goal of suppressing phonological processes. One of the processes treated, stopping, is of particular interest to the present study.

Two children, males, aged four years four months and four years ten months, served as subjects. Each had to demonstrate at least six phonological processes, according to Weiner's (1979) criteria. The processes selected for treatment included deletion of final consonants, stopping and word initial fronting as these processes were present in both boys' speech and would normally have been eliminated by the age of four years.

Weiner constructed four minimal pairs as training items for each process. The first word of each pair was the "target" word. Due to the phonological process pattern exhibited by the children, they would produce both members of the word pair as the second word in the pair. For example, for "stopping" one of the training stimulus pairs was "fin-pin". Due to the operation of the process of stopping, the child would produce both words as "pin". The goal, then, was to have the child, through a game playing format, become aware of his error such that he learned to produce the necessary contrast to make the first word different from the second. Weiner noted that his definition of "correct production" for the purpose of this study was the elimination of the process, not necessarily the correct production of the word. For example, he commented that any fricative in the initial position was accepted as a correct production when stopping was the process involved.

Baseline measures were obtained twice prior to the initiation of treatment in order to ascertain the frequency of occurrence of each process to be treated. The experimental design was a multi-response baseline. There were three phases representing the three different processes evaluated on baseline measures. Generalization probes were administered at each session and differed from the baseline/training stimuli.

Weiner reported that the results of this study indicated that meaningful minimal pairs was an effective approach for both subjects in reducing the frequency of the three phonological processes under treatment. He noted that in both subjects reductions in frequency of occurrence of the processes under study did not occur until treatment was initiated on each, except in the case of Subject A who demonstrated a 5% reduction in stopping in the second baseline measurement on treatment stimuli. He felt this approach was efficient in that these reductions in frequency of occurrence took place in a relatively short period of time (fourteen sessions or less) and that the approach also resulted in reducing the frequency of a number of particular sound errors. Individual differences in rate of progress were considerable in that by the end of the fourth session (twelve treatment trials), Subject A had exhibited a decrease of 70% or better in all three processes under treatment relative to baseline measures (DFC,95%; ST, 95%; F, 100%). This dramatic reduction occurred on target words used as treatment stimuli. Generalization probes using non-training words, however, revealed a more gradual decrease in frequency of occurrence of the three processes, with only two of the processes dropping below the 50% frequency level by the end of the study. Weiner attributed this difference in performance on the two sets of stimuli as most probably indicating a gradual nature of generalization for phonological processes once the necessary contrasts have been established (p. 100). Subject B differed not only in his slower rate of progress but also less total reduction of the frequency of occurrence of the processes under treatment. Generalization for subject B followed the pattern of his change as exhibited in treatment target words, but as with Subject A, it did not approximate the extent of reduction of frequency of occurrence. Weiner interpreted the final performance of both subjects as indications that for them, the meaningful minimal pairs contrast approach was effective in reducing the frequency of occurrence of phonological process.

Cluster Reduction. The phonological process identified as "cluster reduction" in which a child simplifies a consonant cluster at the production level, was the subject of an investigation by McReynolds and Elbert (1981). These investigators referred to a commonly held belief that phonological processes such as "cluster reduction" are general in nature; that is, the operation of such as process would result in simplification of many consonant clusters, not just clusters specific to a certain sound or sounds. In that regard, they questioned whether treatment to eliminate cluster reduction in a few clusters might affect not only the specific phoneme class utilized in training, but other cluster classes as well. McReynolds and Elbert conducted a treatment study to investigate the generalization effects of a given target sound in its production both within and across cluster classes.

Six children who misarticulated [s] and [r] or [l] items on either the Templin-Darley (1960) or Goldman-Fristoe (1969) articulation tests served as subjects. Subjects mean age was 5 years 9 months (range: 4 years 8 months to 7 years 8 months). There were four males and two females in this group. McReynolds and Elbert provided a descriptive breakdown by subject.

Each child selected as a subject also had to meet baseline criteria. A child could not produce [s], [r], or [l] clusters with greater than 10% accuracy in imitative responses across three separate dates. The baseline cluster probe was the same that was used to probe for generalization during treatment. A multiple baseline design was used and two cluster behaviors per subject were involved, either /s/ and /r/ clusters, or in the case of one subject, /s/ and /l/ clusters. Treatment consisted of three phases, and stimuli were imitated by the child. Stimuli for /s/ clusters included [sti], [stæ], [stu], and [sta], administered in that order. Stimuli for /r/

cluster included [tri], then [træ], [tru], and [tra]. Generalization was tested for /s/ and /r/, or /l/ each time criterion was reached in one phase and this provided for across class generalization testing as well as within class generalization. Once generalization reached the 70% level to probe items it was concluded that generalization had occurred and the treatment for that cluster class was stopped, at whatever point in the training sequence this occurred.

Results indicated that within class generalization occurred as the investigators expected though more so for /s/ than for /r/ clusters. All subjects reached the 70% generalization criteria on /s/ clusters following training on /s/ cluster stimuli, indicating that within class generalization was complete for this cluster class. However, in the /r/ cluster class, two subjects failed to reach the same generalization level.

Support for the notion of the general cluster reduction process was lacking as only one subject generalized across cluster classes. The investigators found no evidence of across class generalization in the other five subjects.

McReynolds and Elbert noted one consideration that could affect the interpretation of their findings, that being a problem of insufficiently defining a "process" either qualitatively or quantitatively. They noted that at the time of their study processes were generally considered to be operating on the basis of "occurrences of patterns of articulation errors" (p. 130), but questioned whether the presence of patterns confirms the presence of processes. These investigators acknowledged that the subjects in the present study would be more appropriately described as exhibiting articulation error patterns affecting certain sounds, rather than demonstrating a general phonological process.

This review has presented information relevant to two major theoretical orientations to the treatment of articulation problems, the traditional approach and the cognitive approach. As can be seen, each approach offers its own unique rationale to the origin and remediation of articulation error forms.

Statement of the Problem

A number of questions arise from this review that were addressed in the present study. It was mentioned earlier that many of the children currently receiving articulation therapy are considerably younger than those for whom much of the earlier research and therapy strategies were intended. The first question concerns the issue of relative effectiveness of these approaches in the treatment of misarticulation in the preschool child. The ultimate goal in articulation therapy is to have the child demonstrate correct production of the error sound at the spontaneous speech level. With this goal in mind several questions follow. Does a communicatively centered situation promote faster articulation generalization to the spontaneous level because articulation is more appropriately viewed as integral to the communication process? Or, is misarticulation in this preschool age group related more to phonetic motor ability, in which case it would be expected that learning would take place faster with a sensory-motor approach? The present study examined this question of learning differences in terms of rate of learning relative to each approach. Rate of learning can be determined by the number of sessions necessary for a child to reach a specified criterion level in spontaneous speech. Subjects who demonstrate the same error pattern of stopping for [s] were randomly assigned to one of two treatment methods reflecting the two therapy orientations. The number of sessions necessary for each child to reach criterion was calculated after treatment was completed, and these calculations were used as the basis of comparison between the two treatment groups to determine which differences occurred.

The second major question regarding this preschool group concerns the degree to which articulation therapy affects motor production when using the temporal measures of [s] duration and variability as indices of motor skill.

The traditional approach maintains that development of appropriate sensory motor patterns is essential for speech remediation. The earlier study of Weismer and Elbert (1982) revealed differences in [s] duration and variability in preschool [s] misarticulators when compared to normally articulating peers. Those investigators used these measures as indices of motor control based on Kent's observation that timing is a critical aspect of skilled motor performance. The present study attempted to determine whether a sensory-motor therapy approach did in fact result in improved performance on motor speech tasks. It would follow from the assumption of the traditional approach regarding sensory motor patterns that measures of these related motor control aspects of [s] duration and variability should show improvement following a sensory-motor therapy approach relative to pre-therapy measures, and relative to measures obtained on normal peers. The present study compared performance of both treatment groups on [s] duration and variability at points both pre- and post therapy to determine whether one method produced greater change relative to pre-therapy performance.

Did the [s] misarticulators' performance on the same measures differ from that of the normal subjects? Results similar to those in the Weismer and Elbert study were expected in the present study particularly since these subjects demonstrated a more developmentally immature error form than the subjects in the earlier study. Were there differences in performance however, on these sensory motor measures between the normals and the misarticulators after they had corrected their [s] productions and completed a sensory motor program? Measures on /sV/ and /sCV/ structures on the speech probe were made to determine the mean duration and variability characteristics in the error productions in the experimental subjects prior to therapy. Measures on the same structures were made when each subject had achieved correct [s] production approximately 50% of the time, and after completion of therapy. Similar measures on unaffected sounds [t, d] were also made for comparison purposes. Following therapy the performance of both sub-groups of experimental subjects on the measures just mentioned were compared with the measures made on the normals to determine whether differences among the groups exist after treatment.

A third question relative to the cognitively oriented phonological strategies concerns whether or not these preschool misarticulators who lack the continuancy aspect of [s] demonstrate difficulty in perceptual categorization of /s/ when compared to normal children. The cognitively based phonological approach suggests that the misarticulating child may not be aware of the significance of the missing contrast, and therefore doesn't use it productively. Did these children in fact demonstrate a difference when compared to normals in the ability to successfully perceptually categorize their error sound in tasks involving the stop/continuancy contrast? Were there any changes in performance as a result of treatment under a cognitively based phonological approach which attempts to establish such a contrast? For the purposes of the present study, several tasks were constructed which involved having the child demonstrate correct categorization of stop/continuancy contrasts in both meaningful and non-meaningful /sV/ and /sCV/ constructions. Performance of the experimental children prior to treatment and performance of the normals was compared in terms of number of correct choices to determine whether or not the misarticulating children differ from the normals in the ability to make such judgments. Additionally, comparisons were made following treatment under both approaches to determine any differences in ability relative to treatment approach.

CHAPTER II

INTRODUCTION

The present study was concerned with the relative efficacy of a traditional approach compared to a cognitive communicatively centered approach in the treatment of functional misarticulation in a group of pre-school children. The related issues of whether or not pre-school misarticulating children exhibit motor differences and perceptual differences in ability to categorize error phonemes relative to normal children were also investigated. Two primary groups of preschool children served as subjects in this study, an experimental group and a normal group. The experimental group included children who produced [s] as a stop consonant at the initiation of the study. This particular error pattern is often a part of a general pattern of stopping for many continuants. This experimental group was subdivided into two different treatment groups of two subjects each. The second primary group of subjects consisted of four children with age appropriate speech and language abilities.

SUBJECTS

Recruitment

Subjects were initially recruited via letters informing administrators and area professionals of the general characteristics of both groups of children who were needed for the study (Appendix A). Letters were sent to local pediatricians, two centers for communication disorders, eleven area private schools, five area public school districts and the Beaumont Head Start Program. The letters were followed by phone calls to the various agency administrators and in some cases by visits to the agencies so that further information on the study could be provided. Specific descriptions of the experimental subjects were provided to the speech-language pathologists in the area schools and the communication disorders agencies since they were the professionals most likely to find potential experimental subjects. In addition, interested agencies were provided with parent information letters so that direct contact could be made with the families they served (Appendix A).

The subject selection process involved several phases. First, interested parents contacted the investigator by phone and an initial appointment was scheduled. During the initial meeting the parents were provided with further information about the study and signed release forms allowing their respective children to be tested for possible participation in the study. The investigator also screened the child during the initial meeting with the articulation subtest of the Zimmerman Preschool Language

Scale to determine whether or not there were any indications of the stopping for [s] pattern to suggest that the child should be considered for further testing required for inclusion in the study as an experimental subject. If the child was being considered for one of the normal subjects, then the screening allowed the investigator to determine whether or not the child's speech appeared adequate enough to suggest that he should be considered for further testing to determine inclusion in the normal group. A series of sessions were then scheduled so that a case history review and formal testing could be accomplished. The final phase of the selection process for potential experimental subjects involved the administration of a specially designed speech sampling measure which was used to establish baseline performance levels for each subject regarding [s] production.

Experimental Subject Selection Criteria

In order to participate as a subject in the experimental group the following criteria had to be met:

1. Each child had to be between the ages of 3 years 8 months and 5 years 6 months of age at the time of testing/initiation of treatment.

2. Each had to pass a hearing screening at 25 dB SPL for the octave frequencies 500-8000 Hz bilaterally (ISO, 1964). Testing was performed on an Earscan II, model no. ES2.1TRM.

3. Each child had to score within one standard deviation of the age mean on the Columbia Mental Maturity Scale (3rd Ed., Burgemeister, Blum and Lorge, 1972). This test was administered by a certified educational diagnostician.

4. Each child had to demonstrate adequate structure and function of the oral motor mechanism as determined through the use of the Oral Speech Mechanism Screening Examination (Ruscello, St. Louis, Barry, and Barr, 1982).

5. No child selected could have had previous articulation therapy for any fricative, or continuant errors.

6. Each child had to demonstrate adequate language comprehension by scoring within one and one half standard deviations of the mean for chronological age on the Carrow Test of Auditory Comprehension of Language-Revised (Carrow-Woolfolk, 1985).

7. Each child had to come from a monolingual English speaking home. This was determined during parent interview and from the case history.

8. Each child had to produce [s] as a lingual stop consonant, [t] or [k,g]. Potential subjects had to exhibit less than 20% accuracy of [s] production over each of the three measures which were used to establish the nature and consistency of the error pattern. Two of these measures are commercially available for speech sampling. They are the Templin Darley Tests of Articulation (Second revision, 1969) and the Stopping for Continuants subsection of Weiner's Phonological Process Analysis (Weiner, 1979). The third measure for speech sampling was prepared especially for the present study. A speech probe composed of forty meaningful words and forty spontaneously generated connected utterances was obtained on each prospective subject over successive sampling dates until three complete probes had been administered to each (Appendix B). The probe consisted of words containing ten of each of the phonetic sequences, /sV, sCV, Vs/, and /VCs/. In the words containing the /sV/ and the /sCV/ sequences, /s/ occurred in word initial position, for example, /sei/ and /skaI/. In the words containing the /Vs/ and /VCs/ sequences, /s/ occurred in word final position, for example, /gus/ and /haps/. The probe consisted of two separate phases, the word probe and the

connected speech probe. The single word probe phase was administered in its entirety before the connected speech probe was administered. Each subject produced each word in a delayed imitation response to the examiner's model. For example, the examiner said the stimulus item, and then immediately asked the child "What did I say?". The child then responded with the probe item. Once the child had completed all forty single word responses, he then had to use each probe word in a spontaneously generated utterance so that each probe item could be sampled in connected speech. The examiner instructed the children for the connected speech sampling by using non-probe words for demonstration purposes. In order to serve as a subject each child had to exhibit a stable baseline level of less than 20% correct [s] productions across all three complete probe measures over the three successive samples. All articulation sampling was recorded on audio-tape (see Instrumentation section for description). Articulation test and probe word responses were scored during testing. Spontaneous speech was transcribed from the audiotapes.

It is not uncommon for young unintelligible children to exhibit problems in expressive language therefore two additional standardized language measures were included to provide information on the expressive abilities of the experimental subjects. These two measures were <u>The Test of Early Language Development</u> (TELD) (Hresko, Reid, Hammill, 1981) and the <u>Carrow Elicited Language Inventory</u> (CELI) (Carrow, 1974). The TELD is a broad based screening instrument which involves both receptive and expressive language tasks and relates the findings to the Bloom and Lahey (1979) model regarding language form, content and use. The CELI measures a child's productive grammar by sampling a wide range of grammatical constructions in an elicited imitation format. The CELI was standardized on a white middle class population and was not intended for use with unintelligible children. These two constraints would make it inappropriate under normal assessment conditions for the children in the present study, however, it offered the descriptive advantage of a systematic sampling of utterances in which all of the intended targets (grammatical and phonological) were known. Results of these tests for the experimental subjects are presented in the section on individual subject characteristics in Chapter 3.

Normal Subject Selection Criteria

In order to participate in the normal group, each child had to meet all of the above criteria, with the exception that each had to demonstrate age appropriate articulation ability. The norms for the Templin Darley Test of Articulation were used as the basis for determining whether or not a child's articulation was normal for his age.

Subject Description

Eight subjects participated in this study, four experimental subjects and four normal subjects. The selection process for this study lasted for a period of seventeen months.

Normal Subjects

Normal subject selection was initiated once the number of experimental subjects was known. Subjects were selected in order of application. Three of the normal subjects came from a four-year old pre-school class at the Ridgewood Church of Christ in Beaumont, and one came from the kindergarten class at St. Anne's Tri-Parish Catholic School in Beaumont. The selection process of subjects for the normal group continued only until a number equivalent to that of the treatment group was found. (Four other children, two more from the Ridgewood Church of Christ pre-school, and two from Trinity Methodist pre-school were alternates for testing for the normal group until the first four completed the selection process.) The normal subjects consisted of two males and two females, three of whom were Caucasian and one was Hispanic. The Hispanic male and one female were each 4 years 11 months; one male was 4 years 7 months; and one female was 5 years 11 months old. Table 1 provides information on these subjects' performance on the various testing measures which were used to ensure that they met the criteria for selection.

Experimental Subjects

An earlier pilot study was conducted over the year immediately prior to initiation of this study, and two children were found who exhibited similar misarticulation patterns with the experimental subjects in this study. During the period allowed for this study a total of six subjects were found who exhibited the stopping for [s] misarticulation pattern. All of these subjects were initially found by speech-language pathologists who notified the childrens' families of the study. Of the six

Table 1. Performance by subject of the children in the normal group on subject selection measures

Subject	Age	Sex	Hearing Screening	Oral-Mechanism Examination	CMMS	TACL-R	TD
PM 1	4:7 (55 mos)	M	Passed	Passed	Raw Score:41 %ile Rank:84 ADS:116	Raw Score:92 %ile Rank:94 Total Std Score (T):66 Age Equiv:77-82 mos	P
CP 2	4:11 (59 mos)	F	Passed	Passed	Raw Score:42 %ile Rank:81 ADS:114	Raw Score:84 %ile Rank:85 Total Std Score (T):60 Age Equiv:69:73 mos	P
LG 3	4:11 (59 mos)	M	Passed	Passed	Raw Score:41 %ile Rank:77 ADS:112	Raw Score:74 %ile Rank:71 Total Std Score (T):56 Age Equiv:62-65 mos	P
KH 4	5:11 (71 mos)	F	Passed	Passed	Raw Score:57 %ile Rank:99 ADS:140	Raw Score:96 %ile Rank:82 Total Std Score (T):59 Age Equiv:82-87 mos	P

Note. CMMS: Columbia Mental Maturity Scale
TACL-R: Test of Auditory Comprehension of Language - Revised
TD: Templin Darley Test; P = Passed
ADS: Age deviation score, relative to a mean of 100, and standard deviation of 16

identified, four participated in the study until its completion while two dropped out during the initial testing phase. One of these two developed correct /s/ productions over a school break before the initiation of treatment and was subsequently dropped from the study. The sixth child experienced prolonged absences from school and did not complete the testing phase. She was dropped from the study due to lack of parental response. Of the four children who participated in this study, one came from the Nederland Independent School District; one came from Speech and Language Associates, Inc., a local private practice; and two came from the Beaumont Independent School District's Head Start Program (the two who dropped out also came from this program). All children were found during routine initial speech-language assessments in the respective agencies. All experimental subjects were enrolled in daily pre-school or kindergarten programs during the school year. Each was accepted for the study in order of application.

The experimental subjects consisted of three males and one female subject. Two of the males were Caucasian and one male and the female were Black. At the beginning of treatment the subjects were a male, 5 years 3 months old; a male, 4 years 3 months old; a male, 5 years 2 months old; and a female who was 5 years 1 month old. All four of these subjects demonstrated an absence of [s] occurrence in all baseline measures (with the exception of a one-time occurrence of [sl-] for Subject C2 on the Weiner Phonological Process Analysis) and for varying periods beyond baseline. All four were multiple "functional" misarticulators whose spontaneous speech was generally unintelligible. Each did exhibit some intelligible automatic speech, some imitative words, and some intelligible /CV/ syllables at the time treatment was initiated. According to the Functional Communication

Measure, a severity rating scale used in The American Speech Language and Hearing Association's Program Evaluation System (1987, p. 14-1), these subjects' articulation abilities as just described would be classified as level 2, disordered to a severe degree. A description of each experimental subject's performance on four of the non-articulation measures used in the subject selection process may be found in Table 2.

Subject assignment to treatment approach. Subject pairs from the experimental group were matched on the basis of application order since they were all selected on the basis of similar misarticulation patterns relative to [s] production. Once a pair was selected they were randomly assigned through the toss of a coin to different therapy methods. The subject assignments resulted in the following: one 5 year 3 month old Caucasian male was assigned to the motor approach, and is designated as Subject M1; the 4 year 3 month old Caucasian male was assigned to the Cognitive approach and is designated as Subject C1; the 5 year 2 month old Black male was assigned to the Cognitive approach and is designated as Subject C2; and the 5 year 1 month old Black female was assigned to the motor approach and is designated as Subject M2.

Table 2. Performance by subject of the children in the experimental group on the non-articulation subject selection measures

Subject	Age	Sex	Hearing Screening	Oral-Mechanism Examination	CMMS	TACL-R
1	5:3 (63 mos)	M	Passed	Passed	Raw Score:44 %ile Rank:87 ADS:118	Raw Score:79 %ile Rank:54 Total Std Score (T):51 Age Equiv:65-69 mos
2	4:3 (51 mos)	M	Passed	Passed	Raw Score:20 %ile Rank:16 ADS:84	Raw Score:51 %ile Rank:42 Total Std Score (T):48 Age Equiv:48-52 mos
3	5:2 (62 mos)	M	Passed	Passed	Raw Score:45 %ile Rank:87 ADS:118	Raw Score:77 %ile Rank:52 Total Std Score (T):49 Age Equiv:62-65 mos
4	5:1 (61 mos)	F	Passed	Passed	Raw Score:47 %ile Rank:92 ADS:124	Raw Score:76 %ile Rank:46 Total Std Score (T):49 Age Equiv:63-66 mos

Note. Subject: 1 and 2 were assigned to treatment pair one, in the motor approach and in the cognitive approach respectively.
3 and 4 were assigned to treatment pair two, in the cognitive approach and in the motor approach respectively.
CMMS: Columbia Mental Maturity Scale
TACL-R: Test of Auditory Comprehension of Language - Revised
ADS: Age deviation score, relative to a mean of 100, and standard deviation of 16

Pre treatment articulation ability in the experimental subjects. During the subject selection process, each of the experimental subjects was tested on the Templin Darley Test of Articulation Ability and the Weiner Phonological Process Analysis instrument. The Templin Darley is used to elicit productions of English consonants, consonant blends, vowels, and dipthongs in single word responses. This test is based on the traditional consonant classification model in which each consonant is viewed relative to its position in the word; initial, medial or final. Errors are classified as "omission", "substitution", or "distortion" type errors. The Templin Darley was used because it samples a wide variety of speech sounds and sound combinations of particular interest in this study, and because it provides a suitable basis for a traditional description of articulation ability. Additionally, it is a well recognized standardized assessment instrument for determining articulation proficiency in single words. Table 3 provides a breakdown of articulation performance on the Templin Darley across the four subjects for comparison purposes. All of the experimental subjects were multiple misarticulators whose total number of phonemes in error ranged from twelve to eighteen. "Total number of phonemes in error" refers to all phonemes in which an error of omission, substitution, or distortion occurred in the initial, medial, or final position in words. All subjects demonstrated both omission (range across subjects: eight to fifteen) and substitution type errors (range across subjects: twelve to twenty-three). Subject C1 exhibited an equal number of omissions and substitutions, while the remaining three subjects exhibited more substitutions than omissions. Traditionally, clinicians have viewed omission type errors as more severe than substitution type errors because the indication in the omission error has been that the child was not aware that a sound was present in the position affected, whereas the substitution has been regarded as evidence that the child knew something should go in that position, but didn't or couldn't produce the correct sound. An alternative view for the omission of consonants when they occur in word final positions according to phonological process theory would be to classify such errors as "deletion of final consonants", a production simplification process that the child uses until a later developmental stage.

Three experimental subjects, C1, M1, and C2, demonstrated errors across all of the eight English fricatives, while subject M2 demonstrated errors on six fricatives. All of these subjects exhibited substitution of stop consonants for fricative production. Table 4 provides fricative error analysis across all of the fricatives. Subject C1 demonstrated stopping for four fricatives; M2 for five fricatives; and M1 and C2 each substituted stop consonants for eight fricatives. Both subjects C1 and M2 exhibited correct productions on [f] and [v], while neither subject M1 or C2 evidenced any fricative production. In addition to fricative errors, three subjects, C1, M1, and C2 produced stop consonants for both of the affricatives.

Table 3. General analysis on each experimental subjects' performance on the Templin Darley Test of Articulation

	SUBJECT			
TOTAL NUMBER OF:	C1	M1	C2	M2
Error Phonemes	18	20	16	12
Singleton Omissions	15	18	9	7
Final Consonant Omissions	14	14	5	6
Singleton Substitutions	15	20	25	16
Fricatives in which Stopping occurred	4	7	8	6
Correct Fricatives	2	0	2	2
Affricatives in which stopping ocurred	2	2	2	0

Table 4. Experimental subjects' responses on fricative stimuli on the Templin Darley Test of Articulation

	SUBJECT											
FRICATIVE	C1			M1			C2			M2		
θ	t	-	-	k	-	-	t	-	*	t	t	t
ð	d	j	-	-	k	k	d	-	*	d	d	*
s	t	-	-	k	k	-	t	t	t	k	k	-
z	-	j	-	g	-	-	d	d	-	j	g	-
ʃ	t	-	-	k	l	k	t	t	t	t	t	-
ʒ		j	-		g	-		d	-		j	
f	*	*	-	k	k	-	p	p	t	*	*	*
v	*		-	b		-	b		-	*		*

Note. * = Correct response; - = Sound omitted
Empty Spaces = fricative was not tested in that particular word position

All four subjects substituted a stop consonant for [s] in at least one position. Subject C1 substituted [t] in word initial position, both M1 and M2 substituted [k] for [s] in word initial and word medial position, while subject C2 substituted [t] for [s] in all three word positions. All subjects erred on [s] production in all three positions with omission errors being the only error form exhibited other than stop consonant substitutions. None of the children produced a correct [s] on either the singleton consonant stimuli or the /s/ cluster stimuli. Table 5 provides subjects' responses on the /s/ cluster items on the Templin Darley for comparison.

Portions of the Weiner Phonological Process Analysis instrument were utilized to provide information relative to each subject's production of [s] according to a phonological process model rather than the traditional model represented by the Templin Darley. This instrument addresses three major process categories; syllable structure processes, harmony processes, and feature contrast processes. Weiner described the syllable structure processes as processes which "operate to simplify the structure of syllables" (p. 3, 1979) and feature contrast processes as those which "...account for the

Table 5. Experimental subjects' responses on the /s/ cluster subsection on the _Templin Darley Test of Articulation_

	SUBJECT			
/s/ CLUSTERS	C1	M1	C2	M2
sm-	m	m	b	m
sn-	n	n	k	n
sp-	p	p	p	p
st-	t	t	t	k
sk-	k	k	t	k
sl-	t	l	t	l
sw-	t	w	t	w
spl-	p	pl	b	fw
spr-	p	w	b	fw
str-	t	w	t	fw
skr-	k	w	k	pw
-sm	-	k	t	k m
-st	-	-	t	-
-sk	-	-	t	-
-ks	-	-	-	-
-mps	mp	-	p	m

Note. - = Sound omitted

replacement of one sound by another without reference to neighboring sounds." (p. 5, 1979). Two particular processes, "stopping" and "cluster reduction", were of interest in the present study. "Stopping", considered to be the most common feature contrast process, refers to the replacement of a fricative by a homorganic stop (p. 5, 1979). The "cluster reduction process" was described by Weiner as a syllable structure process in that the child simplifies the syllable production by deleting one of the consonants.

Two types of responses were required of each subject on each stimulus item. The first, a delayed imitation response was performed as a sentence completion response following the examiner's presentation of a stimulus. For example, a stimulus item like the following is provided to the child along with a corresponding stimulus picture: "This is a bowl of soup. Uncle Fred is eating a bowl of .....". The child is asked to complete the response. The immediately following response is the sentence recall response in which the child is asked for example "What is Uncle Fred doing?" with a desired response being "eating a bowl of soup".

Each subject's responses on the "stopping" section are provided in Table 6 for the single word productions. The performance of subjects M1 and M2 on the single word productions of this section were similar to their respective productions across these sounds on the <u>Templin Darley</u>. Subject C1 exhibited an additional stopping error on the delayed imitation response of [v]. Subject C2 exhibited a correct [v] approximation in the previously untested word medial /v/.

Table 6. Experimental subjects' responses on the single word stimuli in the Stopping for Continuants section of the Weiner *Phonological Process Analysis*

SUBJECT

CONTINUANT	C1	M1	C2	M2
s-	t	k	t	k
s-	d	g	t	k
f-	*	k	p	*
-f	*	-	pt	*
v-	f	b	b	*
v-	b	b	b	*
-v-	-	g	*	*
-0	-	k	-	f

Note. * = Correct response; - = Sound omitted

On the subjects' responses to sentence recall tasks, Table 7, subject C1 stopped for [v] both times using [b] once and [d] once. Subject C2 once again exhibited a correct intervocalic, or word medial [v] production. The productions of subjects M1 and M2 were similar once again to their earlier performance on single word production on both the *Templin Darley* and the *Phonological Process Analysis*.

Table 7. Experimental subjects' responses on the sentence recall items on the Stopping for Continuants section of the Weiner Phonological Process Analysis

	SUBJECT			
CONTINUANT	C1	M1	C2	M2
s-	t	k	t	k
s-	t	k	t	k
f-	*	k	p	*
-f	-	-	p	*
v-	b	b	b	*
v-	d	b	b	*
-v-	-	g	*	*
-0	-	-	-	f

Note. * = Correct response; - = Sound omitted

Subjects' responses on the "cluster reduction" section of the Phonological Process Analysis are provided in Tables 8 and 9. Results of performance on this section were consistent for C1 and C2 with their respective performances on the same /s/ cluster items on the Templin Darley. M1 and M2 each demonstrated slightly improved performance on the Phonological Process Analysis on a few items. M1 reduced three word final /s/ clusters (involving /-st/ and /-sk/) to stops on the single word responses, and two of the same word final clusters to stops on the connected speech responses. On his Templin Darley responses for word final /s/ clusters he exhibited omissions of both consonants in both the /-st/ and /-sk/ items. M2 demonstrated her only correct [s] production throughout all

Table 8. Experimental subjects' responses on the Cluster Reduction (initial and final /s/ clusters) section of the Weiner Phonological Process Analysis; single word items

	SUBJECT			
/s/ CLUSTER	C1	M1	C2	M2
sk-	k	k	t	k
st-	t	t	t	k
sl-	t	l	t	l
sl-	t	l	t	sl;hl
sw-	t	w	t	fw
sw-	k	w	t	w
sn-	n	n	t	n
sm-	m	m	p	m
-st	-	k	-	-
-st	-	t	t	-
-sk	-	k	t	-
-sk	-	-	-	-

Note. - = Sound omitted

Table 9. Experimental subjects' responses on the Cluster Reduction (initial and final /s/ clusters) section of the Weiner Phonological Process Analysis; sentence recall

	SUBJECT			
/s/ CLUSTER	C1	M1	C2	M2
sk-	k	k	t	k
st-	t	t	t	k
sl-	t	l	t	fw
sl-	t	l	t	hl
sw-	t	w	t	fw
sw-	d	w	t	fw
sn-	n	n	t	n
sm-	m	m	p	m
-st	-	k	-	-
-st	-	-	t	-
-sk	-	k	-	-
-sk	-	-	t	-

Note. - = Sound omitted

of her pre-treatment testing and baseline measures on the word initial /sl-/ item for the single word production on the Phonological Process Analysis. This response was modified to [hl-] on the /sl-/ connected speech item.

In addition to the Templin Darley Articulation Test and the Weiner Phonological Process Analysis instrument, baseline samples were collected on each subject over at least three successive administrations of both the word and connected speech probes. A description of this sampling process is provided in the section on Baseline and Regular Speech Sampling in this chapter. The resulting baseline measures then, on each subject consisted of 120 [s] production attempts in single words, and 120 [s] production attempts in those same words when used in spontaneous utterances on each subject. None of the four subjects produced an [s] during baseline probes. Additionally, no [s] occurred in any of the subjects probe productions for several sessions into their respective treatment phases.

These descriptions of the experimental subjects' performance across the various pre-treatment measures indicates that they as a group demonstrated similar performance in their attempted productions of [s]. It has further been demonstrated that as a group of misarticulators, they were similar in that they each used stop consonants for some fricative productions, and that they all exhibited stop consonant substitutions for [s].

Additional description of the experimental subjects is provided in Chapter 3 in the section Individual Subject Characteristics.

Descriptive information on each subject was obtained on measures involving perceptual categorization of the error sound and on measures of [s] duration as an index of sensory motor control. These measures will be described under the procedures section of this chapter.

Materials and Procedures

Instrumentation

All speech sampling was recorded on a SONY WALKMAN professional stereo cassette-corder (Model WM-D6C) using Maxell XLII-90 cassette tapes. A Sony electret condenser microphone (Model ECM 150) with windscreen was attached to a cowboy hat and suspended at a stationery distance of two inches in front of and slightly above the child's mouth. This is a low impedance microphone (250 ohms) with a frequency response of 40-13,000 Hz. The acoustic signal was recorded simultaneously on both recording channels via a Realistic mono to stereo jack adaptor (Model #274368) so that the stereo mode could be used for playback. All transcriptions from audiotapes were accomplished through playback over SONY dynamic stereo headphones (MDR-40) or stereo speakers (Midland Model # 21-540). The stimuli for the auditory identification task were played on an Audiotronics (model 800) audiotape cardreader, and presented to the subjects over Realistic headphones (Nova 16). Duration measures on [s] were made using the MacSpeech Lab waveform editing program on a MacIntosh Computer.

Procedures

Auditory Perception Measures

All of the auditory perceptual tasks were carried out in the investigator's office during periods of quiet. Heating and cooling systems were switched off, and rooms adjacent to the testing room were unoccupied during the period of testing. Each subject completed three non-standardized auditory perceptual tasks designed for the present study. All perceptual task stimuli are provided in Appendix D.

4IAX Discrimination. The first task was a four-interval discrimination task (Pisoni, 1971). In this task two pairs of stimuli were presented. One pair was the same, one pair was different. The subject's task was to indicate which pair differed. For example, given the pairs [titi] and [siti], the subject would indicate that the second pair differed.

The examiner used a duck puppet on the right hand and a lion puppet on the left hand. The child was asked to play a game with "duck" and "lion". He was told that each would say some words; one puppet would say some words that were the same, the other would say some words that were not the same. The child was then asked to touch the puppet that said the words that were not the same. Demonstration items were presented using consonants different from those in the actual test items until the child demonstrated understanding of the task through a consistent and accurate response pattern over at least four non-test pairs. The stimuli were presented in subsets of four pairs per set. If the examiner observed that the child lost his grasp of the task or was distracted in any way, demonstration items were repeated at the end of a subset until the child once again demonstrated that he understood the task.

In the first task involving discrimination of singleton /s/ vs singleton stop plosive consonants, designated as /C/, the syllables were of the type /sVsV/ vs. /sVCV/ or /CVsV/ where /V/ was the same vowel throughout all four syllables on any one item. The entire task consisted of three sets of four bisyllabic pairs each. The order of the syllable pairs was randomized for each set. In all, there were twelve choices per task.

The second task was similar to the first in all respects except that it involved auditory discrimination of singleton /s/ in bisyllables vs /s/-stop cluster, for example, [sisi] vs. [sisti]. Both of these tasks were videotaped on a Panasonic VHS movie cam-corder (Model AG-100) and scoring for both tasks was accomplished from videotape replay.

Identification Measure. The third task involved identification involving the minimal contrasts; "see" vs. "tea" and "key"; and "bass" vs. "bat" and "back". These words contrast [s] vs. a voiceless stop consonant [t] or [k] in word initial and word final positions. The stimuli were colored illustrations of the six minimal contrast items. The identification measure was divided into two parts. The first part involved the auditory presentation of the items contrasting the consonants in the word initial position, while the second part contrasted the consonants in word final position. In each of the two parts the respective three pictures were each presented in a three item set, for ten successive sets, totalling thirty presentations and responses. The presentation of items within each set was randomized. During administration of the first part the three pictures representing the words in which /s/ occurred in the initial position were placed in front of the child. Each word, pre-recorded on a tape strip, was played on an audiotape card reader and presented over earphones.

To ensure that the child knew the items involved, each was presented in a non-minimal pair contrast presentation for the child to identify before the formal task. For example, "back" was presented with "tea". The only item that required any assistance from the investigator was the item, "bass" which most of the children missed during its initial presentation for identification. Each child was told that the fish in the picture was named "bass". Upon re-presentation for initial identification all of the subjects pointed to bass when it was named. For the task, each child was instructed to point to the picture named in the auditory presentation. After the first task was completed the words with /s/ occurring in the final position were presented in the same manner. Judgments were scored as correct or incorrect at the time of testing.

All of these perceptual measures were presented on two occasions to the experimental subjects, first at the time baseline measures were made prior to the initiation of treatment, and then again after treatment was completed. Comparisons of performance between the two dates were then made to determine any changes. Results are provided in Chapter 3.

Motor Speech Performance Measures

Motor performance in speech tasks was investigated by measuring temporal characteristics of [s] production in words in connected utterances in both the experimental subjects and the normally articulating subjects. Of interest in the present study were changes in [s] duration and variability. For contrast, similar measures were made on [t] and [d] productions in the experimental subjects.

Stimuli for measurement consisted of the /sV/ and /sCV/ phonetic sequences in the /s/ probe list. Each /s/ singleton or /s/ cluster was immediately preceded by a vowel and followed by a vowel in a pre-determined phonetic sequence such as /maI sup/ or /aI stap/. Ten of the /sV/ and five of the /sCV/ sequences were analyzed for each sampling point (the only /sCV/ items analyzed for this study were those containing the stops /p,t,k/). The sampling of the /sV/ and /sCV/ items took place only once during the initial assessment for each child within the normal group, yielding a total of ten /sV/ tokens and five /sCV/ tokens per child. The experimental subjects, however, experienced the same sampling procedure at three different points in time; pretreatment, during baseline sampling; at that point in time when the child was producing [s] correctly approximately 50% of the time on the probe items in connected utterances; and on the session after the terminal criterion had been achieved. A total of 30 /sV/ and 15 /sCV/ items were analyzed for each experimental subject. In addition, sampling of [tV,dV] or [kV,gV] probe lists were obtained during the pre-treatment period on the first baseline session. At that time these subjects were producing a stop consonant for the singleton /s/, and deleting /s/ in /s/-stop cluster contexts. The particular probes used for sampling depended on the each experimental subject's particular articulation pattern. For example, if a subject produced the stop [k] for [s], then sampling for that child involved both [kV] and [gV] probe lists. If a subject produced the stop [t] for [s], then sampling for that child involved the [tV] and [dV] probe lists. The [tV,dV,kV] and [gV] samples for the experimental subjects were only collected once during the first baseline session. Each of the stimulus words was immediately preceded by a vowel in a pre-determined phonetic sequence. Ten of each of the /CV/ sequences was analyzed for each subject, for example ten /tV/ and ten /dV/.

<u>Method for analyzing motor speech samples</u>. All measurements were made from the audiotaped samples as described in the previous sections, "Instrumentation" and "Motor Speech Production". Analysis was accomplished with the aid of the MacSpeech Lab, Manual Version 2.0, waveform analysis program. The investigator first auditorially identified and recorded the segment of interest from the taped samples. Utterance Recording duration was set for 5 seconds. Each segment was entered into computer memory for immediate analysis. The "spectrogram" layout was selected

and the following parameters were set for the spectrographic display: a) Utterance sample rate was 20K Hz; (b) band width- wide band (300 Hz filter); (c) selection of points to be plotted was set at 5 pt/col. Duration of the segments analyzed was set at two seconds and was represented on the horizontal display. The vertical axis represented the frequency range of 0-10,000 Hz. The MacSpeech Lab program provides the user with two vertical line markers which may be used to mark, move, and analyze the waveform. These left and right markers also indicate the exact time position of each marker in seconds.

Two different duration measures were chosen for the purpose of this study. These measures involved the entire period between vowels in the intervocalic [s] utterance, referred to as the vowel-to-vowel duration period; and the period from the beginning of frication until the end of frication, referred to as the [s] duration period. These were analyzed from the spectrographic display, with the aid of the audio playback and the additional visual information provided in the Time Waveform Window which revealed the progression of the sound pressure level over time in the segment of interest. The time axis within the spectrogram window corresponds to the utterance time wave form which is displayed immediately below. Both spectrographic and waveform information were utilized in these analyses. Specific visual indices used to note vowel boundaries were the beginning and ending vertical striations of the steady states portions of the vowels. These patterns were revealed in particular by their extreme dark contrast which was indicative of their relative intensity. These beginning and ending points were observed and marked in conjunction with the presence of the concomitant peak variations in the time waveform. For example, in determining the end of the first vowel, the investigator attempted to locate visually the vertical striations representing the extreme edge of the most extreme steady state portion of the vowel. Then the investigator located a vertical fluctuation or peak along the time waveform that corresponded with the edge of the steady state portion of the vowel previously located on the spectrogram. The left and right markers would then be manipulated such that the left marker was lined up to intersect both the spectrogram and time waveform at the pre-determined points. The right marker was placed to the right such that a space devoid of any steady state energy was segmented from the rest of the measurement window. The audio playback of the demarcated segment was then used to determine whether in fact any portion of the vowel could be heard. If not, the left marker was moved in increments to the left over the steady state portion of the vowel until some portion of the vowel could be detected to ensure that the closest point to the end of the vowel had been determined. The left marker then was moved back to the right until no portion of the vowel could be heard, and realigned with the two visual points. This method was used to find the beginning point of the following vowel by moving the right marker in the same manner, in the opposite direction.

Periods of [s] frication which appeared on the spectrogram were marked by the presence of aperiodic energy in the frequency range above 4000 Hz, however, aperiodic energy displays characteristic of glottal frication immediately adjacent to [s] frication were also included in the measurement of the fricative duration interval. Audio playback of the segment of interest was used in conjunction with the spectral display in order to help corroborate measurement points. Once the segment was displayed the investigator visually inspected the spectrographic display to determine the points at which aperiodic energy began and ceased relative to the neighboring vowel, stop, or empty space. To find the beginning of the fricative, the investigator would place the right time marker as close to the extreme left edge of aperiodic energy as possible with the left time marker to the left encompassing part of the vowel immediately the fricative. Then the investigator would move the right time marker to the left and then to the right until it was aligned with visual spectra that coincided as closely as possible with the onset of the fricative noise which was heard through auditory playback of the demarcated segment. Often fricative noise and the vowel boundary appeared to overlap in the visual display. At those times unless auditory information contradicted it, the end of the vowel and the beginning of the fricative were considered the same. Determining the end of the [s] was performed in the same manner, with the left marker placed to coincide with the most extreme right edge of the aperiodic energy and the right marker to the right encompassing either the following vowel or the quiet period of stop closure. Once again the auditory playback was used to help demarcate the duration of aperiodic energy.

All measures were recorded in the following manner: for utterances which contained intervocalic stops, measures included (a) end of vowel preceding the stop (b) point of stop release indicated by a separate spike, or sometimes at a point coincident with initiation of the next vowel, and (c) beginning of the second vowel. For utterances containing an intervocalic fricative singleton, measures included: (a) end of the vowel preceding the fricative (b) beginning of the fricative, [s], (c) end of the fricative, [s], (d) beginning of vowel. For utterances containing an intervocalic [s]-stop cluster, measures included: (a) end of vowel preceding the fricative (b) beginning of the fricative [s], (c) end of the fricative [s], (d) point of transitional stop release (e) beginning of the following vowel. The actual point in time for recorded was displayed in seconds immediately under the appropriate left or right vertical marker.

[s] duration and vowel to vowel duration measures. Measures on each subject's utterances were analyzed relative to the vowel-to-vowel duration and the duration of the fricative [s]. The vowel-to-vowel duration was calculated as the difference between the beginning of the second vowel and the beginning of the preceding vowel in milliseconds. This measure was calculated on all subjects, and across all three points in time for the experimental subjects. The [s] duration measure was calculated as the difference between the end of [s] and the beginning of [s] in milliseconds. The [s] duration was calculated for the normal subjects and at the mid-, and post measurement points for the experimental subjects. For the experimental subjects, means and standard deviations in milliseconds (ms) were calculated for each type of [s] utterance, at each of the three points in time, pre-, mid-, and post-treatment points. Means and standard deviations were also calculated for their [tV,dV,kV] and [gv] utterances which were only measured on the one occasion they were obtained. For the normals the measures were made on their intervocalic [sV] and [sCV] utterances for the one occasion obtained.

Baseline and Regular Speech Sampling

The forty item speech probe and spontaneous speech sampling was administered over contiguous sessions until three consecutive and complete speech probes, including both the single item and the connected utterance phases, had been obtained on each experimental subject. These three complete consecutive measures provided the baseline information on each subject. After that time, both phases of the probe were administered in a regular sequence, repeatedly, throughout treatment such that essentially, continuous sampling was occurring on each subject in a systematic manner. Timing of sampling varied across subjects but was similar within pairs. For example, within pair one, both subjects exhibited such reluctance in responding during the initial sessions that their initial sampling measures during treatment were protracted over more sessions than those in the second pair. The second pair in contrast to the first, responded so easily to sampling requirements that their respective speech sampling averaged three sessions for one combined single item and connected discourse probe. Continuous sampling through the regular alternation of word and connected speech probes allowed for observation of the nature of the phonetic changes that occurred and the subsequent determination of the rate at which change took place in each subject.

Reliability

<u>Speech Duration Measurement</u>

The investigator made all of the speech duration measurements for the study. Another ASHA certified speech-language pathologist with extensive experience in acoustic analysis served as an independent judge. Reliability of the vowel-to-vowel and [s] duration measurements was assessed for a group of sixteen words. For each of the eight children, one clustered [s] word and one singleton [s] word was chosen. In a balanced fashion across the experimental subjects, one word for each was chosen from the mid-treatment point, and one from the post-treatment point. All words used for reliability purposes were judged to contain an [s] production. The investigator remeasured these words at a time at least one day later than the original measurement. The independent judge measured the chosen words without knowledge of the previous measurements.

The intrajudge comparisons of [s] durations and vowel-to-vowel durations revealed similar measurements. The [s] duration measurements from the first set of measurements showed an average of 203 ms with a standard deviation of 68. During the second measurement, the mean was 210 ms with a standard deviation of 96. The overall difference between the measurements was not statistically reliable at the .05 level of confidence (t=.370, df=15). Similar results were found for the vowel-to-vowel durations. The first set of measurements showed a mean of 307 ms (SD=159) while the second set produced a mean of 296 ms (SD=154). Again, this difference was not significantly reliable at the .05 level of confidence (t=2.01, df=15).

Interjudge comparisons revealed similar measurement differences. The second judge found a mean [s] duration of 215 ms (SD=106). This did not differ significantly from the primary judge's measurement of 203 ms (SD=68) as presented by t statistics (t=.374, df 15). The second judge found the average vowel-to-vowel duration to be 301 ms (SD=155) which is similar to the original judge's 307 ms (SD=159), producing no significant differences (t=.374, df=15). In general, the reported average measurements for [s] duration appeared to be within a 12 ms range. The average vowel-to-vowel durations were accurate within a 6 ms range.

Assessment of Correct vs. Incorrect [s] Production

The investigator's judgments on correct vs. incorrect [s] productions were compared to those of an independent judge over three taped samples of speech from each subject in order to ensure the reliability of the investigator's assessment of [s] productions in regular speech sampling. Each of the samples had been previously judged by the investigator. The independent judge is a practicing ASHA certified speech-language pathologist with over ten years of clinical experience in articulation treatment. Productions of [s] in all samples were to be judged as correct or incorrect. Each of the three samples on each experimental subject represented the subject's productions of the forty probe words in spontaneously generated utterances at one point in time. The three samples on each subject represented a point near baseline during which time the subject produced [s] with less than 5% accuracy; a point approximating the 50% production accuracy level (mid-treatment); and a point approximating the 75% production accuracy level (post-treatment), respectively. The independent judge was blind as to each subject's treatment approach, and to the sequence of the selected samples. Percentage of agreement was calculated by dividing the number of agreements by the total number of [s] occurrences and multiplying by 100. The results of these calculations of interrater reliability are found in Table 10 for all of the experimental subjects. Agreement on all samples was strong, and was perfect for all three samples of one subject's speech.

Table 10. Percentages of agreement between judges on experimental subject's [s] productions across three measurement points calculated by dividing number of agreements by total number of /s/ occurrences, and multiplying by 100

Point in time relative to treatment period			
Subject	Baseline	Middle	Post
M1	100	92	90
C1	93	90	85
M2	100	95	93
C2	100	100	100

Treatment

The speech sampling and articulation treatment for all of the experimental subjects were conducted by the investigator. At the time the study was initiated the investigator had been a practicing ASHA certified speech-language pathologist for sixteen years. Sessions were scheduled three times a week for subjects M1, C2, and M2. Subject C1 was seen twice a week during the school year due to considerations of excessive distance and his school schedule. After the close of the school year he came three times a week for the remainder of his program. All sessions lasted 30-40 minutes. Sessions began with the regular speech sampling procedure and then the treatment portion of the session began. Exceptions to this sequence and further description of individual subject characteristics, within pair descriptions and between pair differences, and treatment environment differences between the sites where treatment was conducted are provided at the end of Chapter 3, in the section, Individual Subject Descriptions.

The children in the first pair came from school districts outside of Beaumont and were seen in the investigator's office during after-school hours for treatment sessions. The children in the second experimental pair were seen at their school during the school year in a room provided for the investigator to use during the study. These children were seen at school due to family transportation limitations and work schedules. After the end of the school year these children were also seen in the investigator's office but their treatment sessions were scheduled before and after their respective family members' work schedules.

Several characteristics of the two treatment approaches were common to both. First, in both approaches the target sound was established in isolation, both perceptually and productively. Words used on the speech sampling probes were avoided in treatment activities. Some of the words used in treatment activities were the same for both approaches (Appendix E). An exception was the minimal pairs word set used in the cognitive approach which will be described in the section on that treatment approach.

Criterion for termination from treatment was established as the session during which a subject achieved 75% correct [s] productions on the second of two consecutive complete connected speech probes.

Two different treatment approaches were selected for the present study, one representing a sensory-motor approach, an adaptation of an approach described by Hudson (1981) and one representing a cognitive-linguistic approach. Each will be discussed separately.

Sensory-Motor Approach

In the sensory-motor approach, the basic speech unit is considered to be the syllable. This particular approach is one which emphasizes a systematic manipulation of articulatory responses in regard to several key variables. These variables include: frequency of occurrence of the sound, vocabulary, length of utterance in syllables, function/environment of the target sound, mode of presentation, mode of response, and reinforcement of responses. For the purposes of the present study certain adaptations were made to ensure that the sensory-motor approach was more exclusively motor in nature so as to further differentiate it from the cognitive approach. A discussion of each of these variables follows.

Frequency of occurrence of the sounds in spoken English has been cited as a consideration for target selection in articulation remediation. A number of studies (Tobias, 1959; Dorn, 1974; Faircloth and Faircloth, 1973; and Lopez, 1985) have described the relative frequency of occurrence of speech sounds in connected speech. The underlying rationale for including this consideration is that intelligibility could be considerably improved if articulation could be corrected in regard to an error affecting one of the more frequently occurring sounds, than one which occurred relatively infrequently. The phoneme /s/ chosen for the present study is one of the most frequently occurring sounds in English.

Vocabulary in the approach as adapted for this study refers to a closed set of lexical items from which progressively more complex levels of responses were derived. Words were selected specifically to include particular phonetic sequences while being considered appropriate for preschool children. Due to the repetitive drill format utilized in this approach the stimuli served more to fulfill the motor ends of this approach (re: their intrinsic phonetic structures) than as utterances which would be considered as having true communicative intent. The words chosen reflected a diversity of grammatical functions as the longer multisyllabic structures which are appropriate at the advanced levels of this program had to conform to the syntactic rules for English.

Stimulus modality considerations included the use of auditory, visual and visual graphic, or tactile cues, including phonetic placement procedures. Stimuli were sometimes presented utilizing a combination of these modalities as well.

The response mode that the subjects used involved responding immediately following the presentation of the stimuli. Responses were imitative until the final level. In the final response form, the generative form, the subject spontaneously generated utterances containing the phonetic target for which no auditory model was provided.

Length of utterance was controlled in small discrete increments of meaningful syllables. These increments were fixed at utterance lengths progressing from a one syllable length, to utterances two to three syllables in length, to four to five syllables in length, and finally six to seven syllables in length. From this point utterances were generated spontaneously by the subject and varied in length.

The variable of function/environment introduces the notion of a specific classification system which describes the type of phonetic environment in which a consonant occurs, relative to contexts specified in surrounding syllables. There are five basic function/environments for consonants according to this approach:

1. Initial releaser (IR)- a consonant, single or cluster, that "functions" to initiate the first syllable of an utterance which is preceded by physiologic rest and proceeded by a vowel. For example, an initial releaser in the present study will be represented by the /s/ in the stimulus words beginning with /sV/, such as "soup" or [sup].

2. Final arrester (FA)- a consonant, single or cluster, that functions to terminate the last syllable of an utterance which is preceded by a vowel and proceeded by physiologic rest. In the present study, the /s/ in words ending in /Vs/ will be final arresters, such as in the word "goose", or [gus].

3. Abutting arrester (AA)- a consonant, single or cluster, that functions to arrest the first of two syllables and is preceded by a vowel and proceeded by a consonant across syllable boundaries. In the present study, this will be represented by the /s/ in /VsC/ structures. An example would be "this car", [ðis kar].

4. Abutting releaser (AR)- a consonant, single or cluster, that functions to release the second of two syllables, is preceded by a different consonant across syllable boundary and is proceeded by a vowel within the syllable. An example of this would be represented by /s/ in "hot sun", [hat s n] or "do not stop", [du nat stap] which correspond to /CsV/ and /CsC/ phonetic sequences.

5. Intervocalic releaser (IVR)- a consonant single or cluster that functions to release the second of two syllables, is preceded by a vowel across the syllable boundary and is proceeded by another vowel within the syllable. This could be represented by the /s/ in "the soup" or "the star" in which the phonetic sequences of /VsV/ and /VsC/ are both exemplified.

Three of the above function/environment classifications describe embedded contexts which comprise the bulk of spontaneous utterances, while two function/environment classifications describe external contexts (contexts which initiate or terminate spoken utterances).

This approach involves the use of progressively more complex levels of speech production relative to the variables mentioned and levels are modified so that a minimum of variables are changed at each successive level. There are seven levels in all. The sequence of presentation of the various phonetic constructions as enumerated above has been adapted as follows: /sV, Vs, VsV, VsC, CsV/, and /CsC/. In the latter four structures stimuli were selected to allow word boundaries to occur both immediately preceding /s/ in some and immediately following /s/ in others within the same structure to allow for a balanced distribution whenever possible. Criterion levels that must be reached prior to moving to the next sequential level have been set at 80% across two consecutive sessions for the sound in isolation, and 85% across two consecutive sessions for the remainder of the levels.

This approach utilized a highly structured drill oriented format, relying also on fairly explicit response contingent reinforcement procedures. Progressive approximations of the target sound were maintained through the systematic expansion of basic stimulus utterances from single syllable through seven syllable levels (for example; soup, my soup, my soup bowl, my soup bowl broke, etc.) and through branching procedures. If for example, while working on /s/ in intervocalic releaser function/environment in a three syllable response, the child failed two consecutive attempts, the clinician dropped down to the two syllable level on the same utterance.

The focus of this particular treatment approach is its systematic attempt to establish appropriate speech changes in contexts carefully controlled for length and presumed phonetic contextual complexity. Motor considerations are predominant here in the choice of the syllable rather than the word as the basic unit within which the target sound is approached. Its emphasis on motor aspects is evident also in the assumption that establishing and maintaining an accurate production of the target sound is facilitated if utterance length (in syllables) is controlled. This approach treats speech as occurring at a relatively low level in regard to the Kent and Minifie model which was explained in Chapter One. That is, this approach is oriented to the motor production output level. Again, consistent with the assumptions of a sensory-motor approach, it is assumed that the individual must work up progressively through each successive level from that level at which he began in order to establish and maintain correct production, at the terminal stage, generative speech, or spontaneous conversation. Correct articulation then, of the target segment(s) is seen as developing in a leg over leg fashion until the complete heirarchy of levels has been mastered. Treatment was terminated when a subject reached terminal criterion for the study.

The Cognitive Approach

In the cognitive approach, the target sound is considered relative to the word within which it occurs under the assumption that the individual thinks and speaks in words. The notion here is that if the child knows that a given target segment has contrastive significance for his language which affects meaning (i.e. as in the case of "see" vs. "tea") and knows the allowable sequences in which they may occur in a given language (i.e. /s/ may occur in word initial, medial, and final position; /s/ may immediately precede /t,k,n,l/ etc. in cluster formations within words in certain words positions etc.) then the physiological functioning involved in speech production should readily accommodate his productive knowledge. Dinnsen et al. (1984) have distinguished productive phonological knowledge from phonological knowledge as being that phonology system evidenced in the child's speech productions without assuming knowledge otherwise. Essentially, then this treatment approach reflects a focus on a higher cognitive level than that of the sensory-motor approach. This approach would maintain that in the case of the child who stops for [s], the child may not in fact know that there is a contrast between /s/ and /t/; or he may not realize that such a contrast has significance in English. This approach assumes that the production system as illustrated in the Kent and Minifie model will act in accordance with what occurs at the upper or more cognitive level without requiring specific training and that there is no substantial sensory motor deficit. In other words, productive knowledge reflects the child's phonological knowledge.

The cognitive approach uses a communicatively interactive approach between the investigator and the subject, in direct contrast to the drill oriented imitative format of the sensory-motor approach. Directed play activities were utilized to keep the atmosphere relaxed and naturally spontaneous while focusing on opportunities to present the child with stimuli containing the phonetic target. Imitative drills were avoided. Activities used in this approach, particularly initially were designed to emphasize differences between the target sound /s/ and the contrastive error form such as /t/ by demonstrating how meaning was affected when an error was made. A conversational interaction between client and clinician was emphasized as much as possible.

This approach proceeded as follows. First the clinician used visual graphic and auditory stimuli to establish the /s/ sound as the intended target for change. The /s/ sound was named the "s sound" and also referred to as the sound that a snake makes, the "snake sound". Each child learned to identify and produce the [s] sound in isolation as the first step in this approach. Once the child could consistently produce the [s] sound in isolation (75% of the requested trials) the child moved immediately to production of the sound in words.

The children in this approach began production of [s] in words through a procedure referred to as a minimal contrast procedure, in which a child was made aware of contrastive differences between the desired target sound /s/, and his error production [t]. The first words introduced were a closed set of minimal contrast pairs consisting of monosyllabic words with /s/ occurring in word initial position. This set included the following words: two, Sue, tub, sub, Tad, sad, tip, sip, tock (picture of a clock presented with "What does a clock say?") and sock. Each word was represented by a picture on a 3x5" card. Three words were taught to each child as they were introduced. These included the two words which were proper names, Sue and Tad; and the item "sub" which was introduced with its picture representation as well as a toy submarine. The pictures were presented and the child had to correctly identify each over two consecutive tasks in which the clinician spread all pictures out and challenged the child to show her each item once it was named. The words were presented to the child as "s" words and "t" words and as

[s] words and [t] words as well.

Once the child could identify all of the words, this game switched to a game in which the child had to produce the words represented by the pictures. Pictures were presented several ways but in each game format the child had to correctly name the word on the first trial in order to keep it. The winner always was the one with the most cards at the end of the game. Games included "concentration" in which subsets of the ten card pairs were presented in duplicate. The child had to say each picture when he turned over the card. If he missed it he lost his turn. The one who won the most duplicate pairs won the game. In a game similar to this, all cards presented were single sets of minimal pairs placed face up on the table. The child was instructed to name a picture for the clinician to point to. Since /s/ words were all produced with [t] for [s] initially by the experimental subjects, the clinician pointed to the /t/ word which the child produced. If the clinician pointed to a card which was not that intended by the child he would let the clinician know that was the wrong card. The clinician would then respond with "Oh, you meant the /s/ word, Sue, but you said the /t/ word, two. Try it again like this" and then the clinician would produce the word correctly and allow the child to attempt again. Throughout all of the games using the minimal pairs, the subject's incorrect responses were brought to his attention in this manner so that the contrast was emphasized explicitly for the child and he was made aware that his message or "intent" was not realized because he named something other than he intended. Each subject was encouraged to monitor his own productions and tell the clinician when asked whether or not he produced the word correctly.

Once the subject could correctly produce all of the /s/ words correctly over consecutive sessions, he was allowed to use them in connected utterances in the game "Go Fish". No constraints were placed on the structure or length of the utterances. For example he could say "give me a sub" or "let me have your sub". He was required to name the item desired in a connected utterance. Also at this time new /s/ words were introduced in games like the ones previously mentioned in which one word responses were used. These words contained /s/ in word initial as well as word final positions, and in clusters. As with the first set of words, once the child was able to consistently produce new words with correct [s] productions over consecutive sessions at the single word level then new games were introduced which encouraged use of the words in connected utterances. For example in "Grab Bag" or "Secrets in the Sack" the child was allowed to reach into a sack and retrieve an item or a picture. He had to tell the clinician something about the item and use its name when he talked about it. If a subject made a mistake on an [s] production in an utterance the clinician would repeat back the entire response just as the child produced it indicating that she didn't understand the message. The child could show her his item at which time she would say, "Oh you meant...." and indicate as mentioned earlier that he had used a /t/ word for an /s/ word and that was why she didn't understand him. Other games included use of the extremely popular "S Machine" which was a battery operated rolodex with /s/ stimulus pictures on the flip cards; and taking turns "hiding" /s/ items in the room and letting the other person go find it. Once found, the person had to talk about what he found. Games were adapted for word or connected utterance level responses. Treatment continued until a subject reached terminal criterion.

To summarize, this study is investigating three major questions. Each question will be discussed separately along with the comparisons necessary to address that question. Due to the small number of subjects involved relevant comparisons were made on the basis of visual inspection of the data.

Experimental Design

This study was designed to investigate several questions. The primary focus of the study was to determine the relative efficacy of two therapy approaches, the cognitive approach and the sensory motor approach, in the correction of [s] misarticulation in a group of preschool children. The first issue addressed was whether the children in one approach achieved the 75% [s] production accuracy criterion in connected speech in fewer sessions than children in the other approach. The dependent variable here was the rate of learning which has been operationally defined in this study as the number of sessions necessary for a child to attain the terminal criterion level. Accuracy of [s] production was determined by the investigator's judgments of both live and taped [s] productions by each child on the probe stimuli in connected utterances. All [s] productions were classified as correct or incorrect.

The percentage of [s] productions in connected utterances based on the forty probe items was calculated for each child on each sampling date on which a probe was completed. The number of sessions necessary for each child to reach the 75% accuracy criterion on the second consecutive complete probe was calculated and compared to the number of sessions necessary for his match to reach criterion in the other treatment group. Additionally, line graphs were made depicting each subject's progression over time in terms of percentage of accuracy of [s] production to aid in the description of the individual subject's learning patterns. Separate graphs were also made for each subject to demonstrate specific learning patterns relative to the /sV-/ and /sCV-/ lexical shapes on the word probe, and a separate set were plotted for each subject's progression on each structure in connected utterances. An analysis of emergence of lexical shapes by subject was performed to determine whether there were any differences in order of emergence by treatment type.

Another comparison was made on the number of responses allowed per session for [s] production by treatment type as this has been considered by some to be related to articulation learning, and could therefore influence rate. The number of responses involving [s] production were recorded for each child at every fifth treatment session. These subtotals reflected only those responses made during therapy and did not include those made during administration of the probes. These subtotals were then added together for each subject at the completion of treatment. The mean of the total number of responses was obtained for each child for an estimated mean number of responses and compared to that of his match in the other treatment approach. A comparison across these means was made by visual inspection for subjects within treatment pairs. These differences between subjects within treatment pairs were then compared to the results of length of treatment by subject. It was expected that the sensory motor approach would yield more responses per child per session than the cognitive approach due to inherent differences in the methods.

Did the children who exhibited the greater number of responses per session also reach the final criterion in fewer sessions than their matched subjects in the other approach? This information was obtained by comparing the results of the comparison on number of responses per session by treatment type to the results of treatment type in terms of length of time to reach criterion. If the amount of phonetic production practice is more critical to rate of articulation learning than the cognitive level considerations of the cognitive approach, then the children in the sensory-motor approach would be expected to complete correction of the /s/ in fewer sessions and with a greater number of [s] productions per session than their subject matches in the cognitive approach. If on the other hand, the children in the cognitive approach completed [s] correction in fewer sessions and with fewer responses per session than their matches, the assumption that the motor system will accomodate the child's phonological knowledge of contrasts without extensive motor training would be supported.

The second question addressed the issue of whether sensory motor differences were evidenced in the speech production tasks between a group of misarticulating pre-school children who stopped for [s] and a group of their normal peers. In the earlier study by Weismer and Elbert (1982) as mentioned in the literature review, differences were found in the temporal characteristics of both correctly articulated sounds and incorrectly articulated sounds in four to six year old [s] interdentalizers and normally articulating children of the same age. Since the experimental subjects in the present study exhibited a more developmentally immature error form for [s] than those children in the earlier study, similar findings involving group differences in [s] duration means and standard deviates were expected in the present study.

The sensory motor measure used as the basis for investigation of this question consisted of the productions of intervocalic /sV-/ and /sCV-/ sequences in connected utterances which were collected on each child as described in the section on Motor Speech Production. A number of comparisons were conducted on this data. To begin with, the second question has focused on differences in [s] duration between normally articulating children and children who stop for [s]. Comparisons which were directly relevant to this question were described first, i.e. those comparisons involving the individual experimental subjects compared to the normal subjects; and then group comparisons. Individual and group means and standard deviations relative to the [s] duration measures were calculated in milliseconds based on a specified number of tokens for each subject according to each phonetic context at each of the sampling points. The actual [s] durations were measured at only the mid-treatment and post-treatment points, whereas the vowel to vowel measures were made at pre-treatment as well as mid- and post-treatment points. The vowel to vowel measures were the ones which allowed for the comparison of mean durations of pre-treatment intended stops, the error stops for [s], and then the later developing [s] productions.

There were four means obtained for [s] duration measures for the experimental subjects as a single group, one for each phonetic context at each of the two sampling points. Comparisons between the normals and the experimental subjects were made relative to their respective group means for [s] duration in both phonetic contexts, in which the same data sets for the normals' is compared against the changing data for the experimental subjects across the two data points.

There were seven means obtained on the experimental subjects for the vowel to vowel mean durations; one for each phonetic context sampled at the pre-treatment point (intended stops, which were only sampled at the pre-treatment point; [s] singletons, which at that time were error stops, and [s] clusters, which at that time were reduced to stops); the mid-treatment point and the post-treatment point. If findings similar to those in the Weismer and Elbert study in terms of the presence of differences occur in the present study as expected, then the differences should be greater between the two groups at the point when the experimental subjects are demonstrating 50% [s] production accuracy and less at the point when they have reached the final criterion.

The comparison between the mean of the normals and that of the misarticulators after correction of [s] should be particularly relevant. It was of interest whether the experimental subjects as a group still exhibited differences in the temporal characteristics of [s], relative to the normals, after [s] production was established at criterion.

In fact, the traditional assumption of the sensory-motor approach has been that misarticulation is due to deficiencies in sensory-motor skills in speech. The therapy approach used in this study to represent the sensory-motor paradigm was selected according to the assumption that in order to correctly remediate /s/, the child needs to develop appropriate motor patterns associated with the target sound production in a variety of phonetic contexts. It would seem that following correction of the sound, the normally expected sensory motor skills should also have been acquired. It was expected that the children who were treated under the sensory motor approach would demonstrate similar temporal characteristics in correct [s] production relative to the normally articulating group. For this approach, it was particularly relevant that a comparison between the normal group and those of the children who completed the sensory motor approach should be made. Additionally, a comparison of mean [s] durational characteristics of the individual children who completed the sensory motor approach would also be relevant. It would be expected that the means of the individuals who completed the sensory-motor approach would more closely approximate the mean [s] duration of the normal group due to the extensive phonetic production practice experienced in that approach. Though the phonological approaches are based on the assumption that once the necessary phonological contrast is established in the child's lexicon, the motor system will accomodate, a child experiencing the cognitive approach might not be expected to demonstrate the degree of precision in [s] production that the child from the sensory-motor approach would be expected to develop. This "precision" in motor skill would be evident in the subject's temporal characteristics of correct [s] productions.

Another very important comparison was that of determining the degree of change in mean [s] duration relative to the normals' group mean for the children in both treatment groups from the initiation of therapy to its completion. Measures from the first sampling date and the last sampling date for the individuals in both treatment groups respectively were used. It was expected that the degree of change on this sensory-motor measure should be greater for the children who experienced the sensory motor approach than those in the cognitive approach, once again due to the extensive phonetic practice.

Another comparison was conducted on the stop substitutions the misarticulating children used for [s] and the same stop consonants in their normally intended contexts. As mentioned previously the stimuli for this comparison were the /sV, tV/ and /dV/ probe items. Each was preceded by a vowel. The measures as previously described under the procedure section were used to determine whether the misarticulating subjects demonstrated any duration differences between the stops that are produced in place of [s] and the same stops in their normally intended forms. The misarticulating subjects' group means for /sV, tV/ and /dV/ productions were compared in the following way; the mean for the normal subjects' [sV] productions was compared to the mean and standard deviations of the experimental subject's productions. Since this measure was made during the baseline period the /sV/ probe items would be expected to contain stops in place of [s]'s.

The third general question addressed in this study was that of whether or not these pre-school misarticulators who lacked the continuancy aspect of [s] demonstrated difficulty in tasks involving perceptual categorization of /s/ when compared to the performance of the children in the normal group. As mentioned earlier, an assumption common to the phonological approaches is that the misarticulating child does not realize that a particular phonological contrast, such as stop/continuancy, has significance in his language, and he therefore does not use the contrast productively. A goal then of the cognitively based phonological approaches has been to establish the targeted contrast as a meaningful one through communicatively centered activities. Once the child realizes that the contrast is meaningful, then theoretically he will use it productively. The third purpose of this investigation then was to determine whether these misarticulating children did in fact evidence more errors in categorizing auditory stimuli that differ in the stop/continuancy contrast, than the children in the normal group. In order to establish whether or not differences exist between the normal group and the misarticulating group, the auditory perceptual tasks described under the procedure section were administered to both groups. The normals completed the two perceptual measures (each was divided into two tasks) once during their respective assessments. The experimental subjects completed the tasks at two points in time, during the pre-treatment baseline period and after completion of treatment.

There were a total of 12 responses for each of the first two tasks in the first perceptual measure, and 60 for the second measure (30 responses for each of the two tasks). The performance of the subjects in the normal group was compared to that of the subjects in the experimental group in a ranking procedure across groups in order to make visual comparisons of the relative performance differences between the members of the two groups at a pre-treatment point, and then the experimental subjects respective performances was once again compared to the normal subjects' performances, but this time after treatment was completed.

Another question related to the development of awareness of the stop/continuancy contrast is whether or not the children in the cognitively based phonological approach exhibit a change in performance in perceptual categorization tasks at the completion of treatment. Since the cognitive approach explicitly seeks to establish the stop/continuancy contrast for /s/, change from pre-treatment performance to post-treatment performance would be expected when possible. Each child's total correct for each of the three tasks at the pre-treatment point was compared to his total for each task following treatment. It was expected that a consistent tendency of improvement, (if improvement was possible) represented by larger totals on each task at the post-treatment measure, would result for each child within the cognitive treatment group.

In order to determine whether there were any differences in ability to correctly make these perceptual categorizations of the stop/continuancy contrast with /s/ as a function of treatment type, an analysis within treatment pairs was made relative to change from pre-treatment to post-treatment performance. The difference in the number correct was determined for each child between his pre- and post-treatment judgment totals so that comparisons could be made relative to treatment type. Though the cognitive approach is based on establishing stop/continuancy contrast, the ultimate goal for both groups was correct production of [s] so following completion of treatment the contrast would have been established regardless of treatment type. However, as the emphasis in the cognitive approach was that of recognizing the stop/continuancy contrast as significant where [s] is concerned, the children who experienced that approach could have demonstrated greater relative improvement as a group.

CHAPTER III

The purpose of this investigation was to compare the relative effectiveness of two articulation treatment approaches in the remediation of misarticulation in pre-school children. The two types of treatment approaches compared in this investigation were a sensory motor approach and a cognitively oriented approach. The questions addressed in this investigation concerned the presence of differences in learning rate relative to treatment approach; whether articulation treatment affected sensory motor ability and whether such effects were treatment specific; whether /s/ misarticulating preschoolers demonstrated differences in the ability to perceptually categorize their error sounds in tasks involving stop/continuancy contrasts, and whether treatment type would differentially improve this ability. A description of the findings follows.

[s] DEVELOPMENT OVER TIME AS A FUNCTION OF TREATMENT TYPE

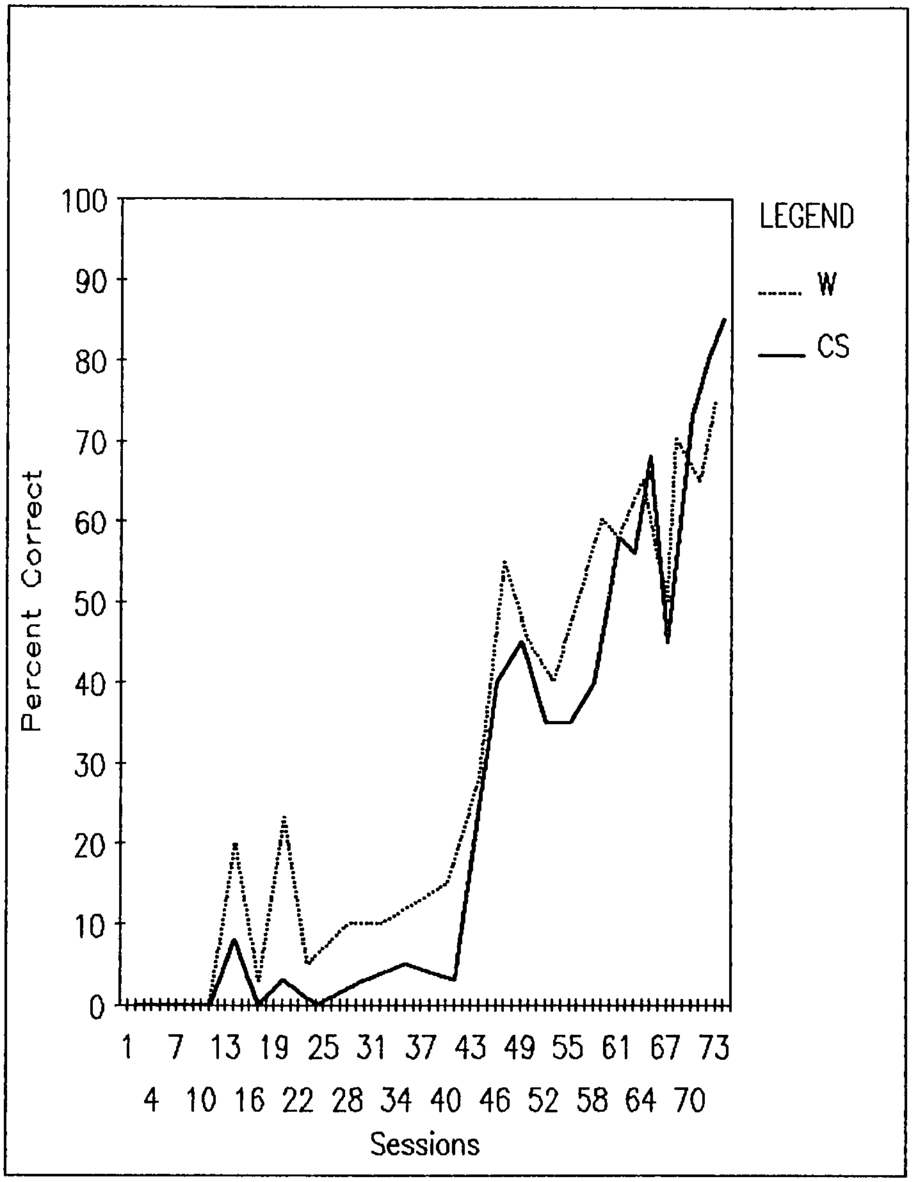
The primary question posed by this investigation was whether articulation treatment type differentially affected the number of sessions needed to attain a certain result. In order to address this question, treatment results will be presented relative to a series of related topics, with each topic discussed first by individual subject, and then by the appropriate group, depending on the nature of the data under discussion. The topics in order of presentation are: individual progressions in [s] correction relative to number of treatment sessions necessary to attain terminal criterion; learning patterns relative to the 25% level of production accuracy and the 75% level of production accuracy of [s] production in spontaneous connected speech, and in single words; relative time difference between attainment of a given production accuracy level in words to the same level of accuracy in connected speech; emergence of lexical shapes with particular emphasis on /sV-/ and /sCV-/ shapes; relationship between order of teaching of lexical shapes and order of emergence; and the average number of [s] productions per session relative to treatment type.

The progress of each subject through his respective treatment program will be described relative to two levels of [s] production accuracy, the level at which 25% of his [s] productions were correctly produced, and the point at which at which 75% of his [s] productions were correct. For each subject, performance on both the single word probes and the connected speech probes will be described relative to these two percentage of accuracy levels. The earlier level of production accuracy will be referred to as the "25% level of production accuracy" and the later level will be referred to as the "75% level of production accuracy". Terminal criterion, the second consecutive connected speech probe on which the subject scored 75% correct [s] productions, will be discussed separately. For each subject, line graph representations of his [s] development in terms of percentage correct over time as measured separately on both the word and connected speech probes, respectively, will be provided. Each line graph progression represents the time period from the first treatment session to the subject's own terminal criterion. All treatment periods are graphed relative to that of the subject who required the greatest number of sessions to attain criterion. This subject, subject M1, required 74 sessions, therefore, all of the subject's respective treatment progressions are depicted proportionately relative to that maximum time period.

Description of Learning Patterns Related To [s] Development

Description of [s] Development by Individual Subject

Subject M1. Figure 3 represents subject M1's development of correct [s] productions. Production accuracy levels for both word and connected speech remained below the 25% accuracy level until the 44th and the 46th sessions respectively (62% of the length of his treatment program). In connected speech a sharp rise occurred between the 41st and 46th sessions. This rise was due to



<u>Figure 3.</u> **Subject M1's development of [s] production in single words and in connected speech over time to terminal criterion.**

an abrupt increase in accuracy of [s] production of from 0% correct to 30-40% production accuracy of /sCV-/ and /VCs-/ lexical shapes as well as a dramatic increase of from 10-90% correct on the /VS-/ lexical shapes, all of which occurred on the 46th session connected speech probe. A similar rise occurred in the word measure with a climb of 15% to 55% correct. This increase was due to a 60% improvement in /sCV-/ lexical shapes and a 40% improvement in /Vs-/ lexical shapes which occurred on the 47th session word probe.

After the 46th session, subject M1's progression to criterion in connected speech was uneven. A sharp downward trend occurred on the 67th session due to a 20% decrease in correct [s] productions. This decrease was due to reduced accuracy of production on /sV-/, /sCV-/, and /-Vs/ lexical shapes. The subject had missed four sessions immediately preceding this session due to illness. Following the 67th session probe, subject M1 exhibited a steady upward trend over the next three consecutive connected speech probes to criterion on the 74th session.

Subject M1's 25% production accuracy level for words and connected speech occurred within two sessions of each other. The same was true for his 75% accuracy of production level, since he achieved 75% accuracy of production in words on the 73rd session. Overall, this subject's connected speech performance generally shadowed his [s] production performance on the single word probe from the first treatment session to criterion. (Subject M1's entire treatment program covered a time span of 7 months, during which time he averaged 10 sessions per month.)

Subject C1. Subject C1's progression in [s] development in both word and connected speech measures is illustrated by the combined line graph in Figure 4. Connected speech performance was stable below the 25% production accuracy point until the 16th session, at which point [s] production on the word probe also reached the 25% production accuracy level. From that point subject C1 made little substantial gain in correct [s] productions in single words until the 44th session when he attained the 50% production accuracy level. Prior to this point on single word probes, this subject exhibited stable production of all of the /-Vs/ probe items, and was establishing production of /sCV-/ items. Subject C1's production of /VCs-/ items was minimal, however. This sudden upward trend on the 44th session in [s] production on single word items was directly attributable to subject C1's first successful productions of the /sV-/ probe items and improved performance in /-VCs/ items. At this point for the first time on single word probes subject C1 exceeded a 25% production accuracy level on all four of the lexical shapes represented on the probe.

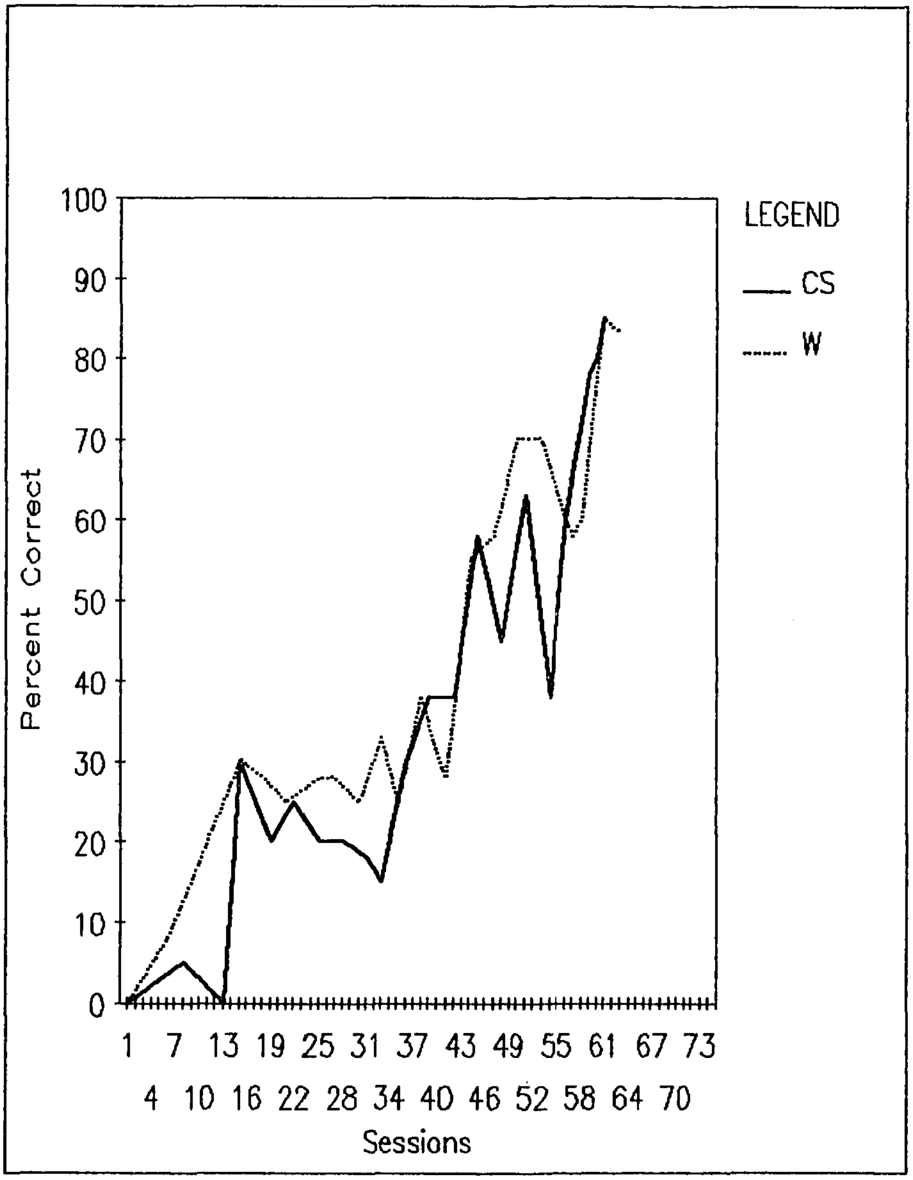


Figure 4. Subject C1's development of [s] production in single words and in connected speech over time to terminal criterion.

Development of correct [s] production in connected speech for this subject was extremely variable between the 50% accuracy of production level on the 46th session and the 57th session. Variability of performance was evident in all lexical shapes except /Vs-/ shapes which Subject C1 produced with complete accuracy from the 40th session to criterion. Beginning with the 57th session subject C1 demonstrated a sharp upward trend in connected speech for three consecutive sessions to criterion on the 61st session. Subject C1 attained his 25% level of production accuracy on words and connected speech on the 15th and 16th sessions respectively. He attained 75% accuracy of production on a connected speech probe for the first time on the 60th session, and on the 61st session on the word probe. (Subject C1's entire time period of treatment covered a span of 9 months, during which time he averaged 7 sessions per month).

Subject M2. Subject M2's /s/ developement is presented in Figure 5. Accuracy of production in single words preceded and exceeded that in connected speech until the 26th and 27th session probes. Beginning on the 26th session connected speech probe, this subject began to produce all lexical shapes accurately to some degree with the /sV-/ shape being the last to emerge. Once this last lexical shape emerged, subject M2 attained a 50% production accuracy level almost immediately on /sV-/ probe items and

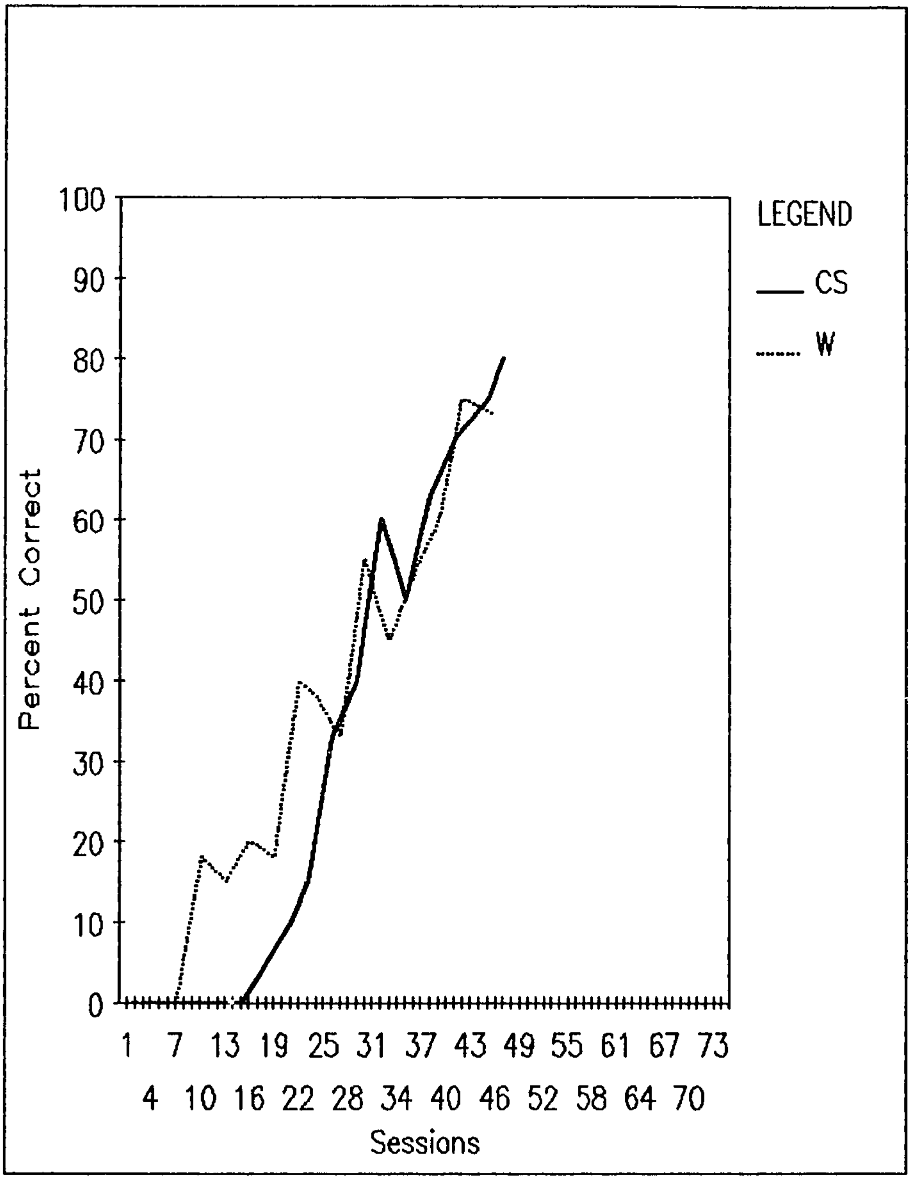


Figure 5. Subject M2's development of [s] production in single words and in connected speech over time to terminal criterion

continued to improve steadily on them. Following the 26th-27th sessions, subject M2's word and connected speech performance progressed together to criterion. Subject M2 attained or surpassed her 25% level of production accuracy in words and connected speech on the 22nd and the 26th sessions respectively. She attained her 75% level of production accuracy on words and connected speech on the 42nd and the 44th sessions respectively. Subject M2 reached terminal criterion on the 46th session. (Subject M2's entire time period for treatment covered a span of 5 months during which time she averaged 9 sessions per month.)

Subject C2: Figure 6 depicts Subject C2's [s] development over his entire treatment period. Accuracy of [s] production at word level preceded and exceeded the development of [s] production at the connected speech level for this subject until the 33rd and 35th sessions. Until those probe sessions, Subject C2 produced the /sV-/ and /-Vs/ lexical shapes with considerably greater accuracy at the single word level. A sharp rise in his [s] production accuracy in single words occurred on the 15th session at which time this subject produced his first /-Vs/ lexical shapes and produced 70% of them correctly. A more pronounced rise occurred on the 21st session at which time subject C2 was able to produce all four of the lexical

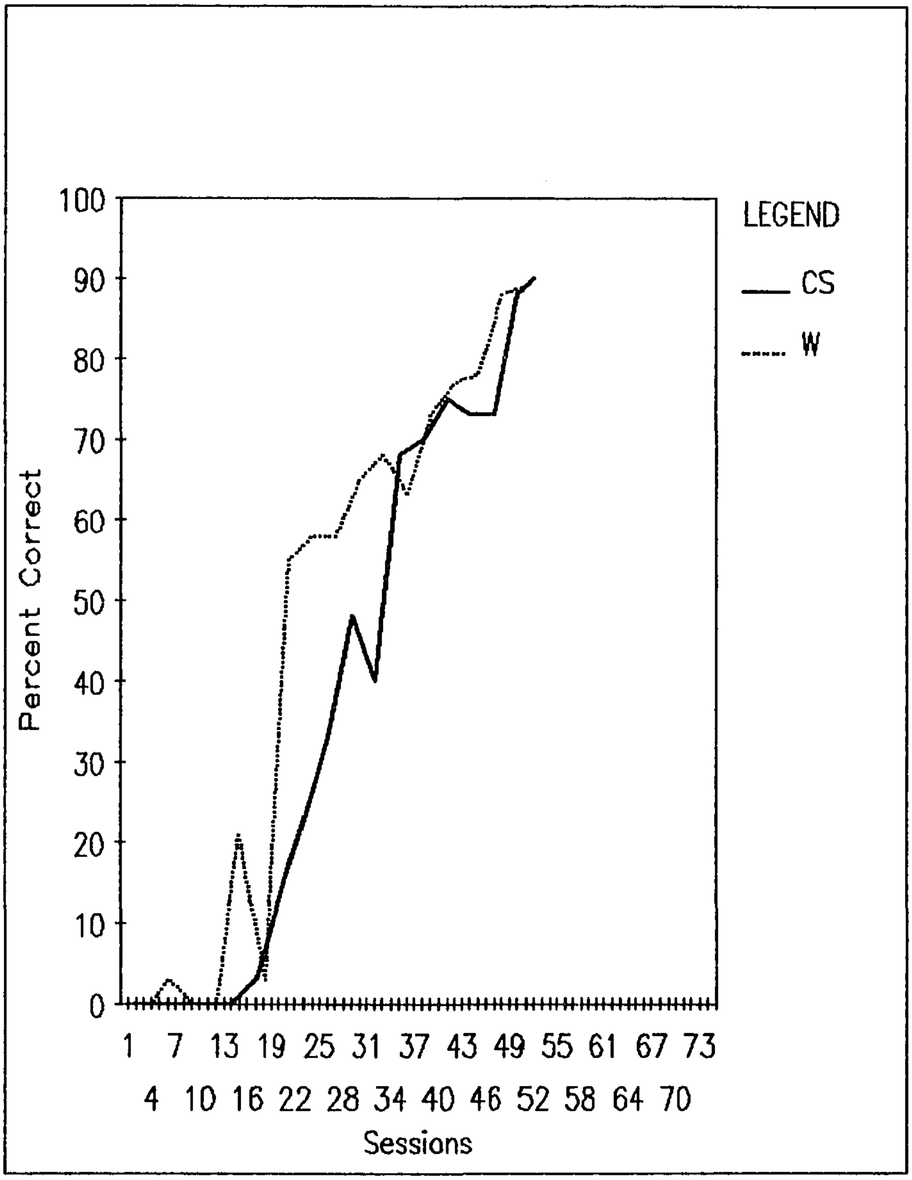


Figure 6. Subject C2's development of [s] production in single wordsand in connected speech over time to terminal criterion

shapes. Prior to that session, subject C2 had not produced any /sV-/, /sCV-/, and /-VCs/ lexical shapes. Subject C2's [s] production in connected speech reached a 25% level of production accuracy on the 26th session. Fairly steady increases in production accuracy in all four lexical shapes contributed to this subject's continued upward trend in connected speech to criterion on the 52nd session. Subject C2 progressed to a near 25% production accuracy level, regressed to baseline and then suddenly attained the 55% production accuracy level in word productions on the 21st session. He attained his 25% accuracy of production level in connected speech on the 26th session. He achieved a 75% production accuracy level for the first time in connected speech on the 41st session, and in single words on the 42nd session. Although this subject attained 73% accuracy and better for three consecutive probes following his first 75% accuracy level he did not attain true criterion until the fourth consecutive connected speech probe. This occurred on the 52nd session. (Subject C2's time period for treatment covered a span of 6 months during which time he averaged 9 sessions per month.)

Description of [s] Development Within Treatment Pairs

In pair one, Subject C1 attained final criterion on the 61st treatment session and his match, M1, attained final criterion on the 74th treatment session. A comparison by visual inspection of their respective graphs depicting the progression of each through treatment (Figures 4 and 3) reveals two different patterns regarding the point in time at which each attained his 25% production accuracy level in connected speech. Subject C1 reached his 25% production accuracy level relatively early in his treatment program (16th session) compared to the point at which Subject M1 reached his same production accuracy level (44th and 46th sessions). Subject C1 spent the remainder of the length of his treatment period (approximately three quarters of his treatment period) gradually progressing toward criterion. Subject M1 spent the majority of his treatment period (sixty percent) attaining the 25% production accuracy level and the remaining forty percent of his treatment period attaining criterion. Though each subject demonstrated some relatively sharp inclines relative to his own total progression toward criterion, their overall learning patterns reveal gradual inclines toward criterion.

In pair two, Subject C2 reached final criterion on the 52nd session, whereas his match Subject M2 reached final criterion on the 46th treatment session. Subject C2 did reach the 75% accuracy of production in connected speech for the first time on his 41st session, he scored 73% correct on the next two consecutive connected speech probes, followed by an 88% and 90% on the next two connected speech probes. Technically then, final criterion was not reached until the 52nd session when Subject C2 achieved his second consecutive score of 75% or better, which in this case was 90%.

Subject C2 and Subject M2 each attained the 25% production accuracy level on the 26th session, a point approximately midway through each subject's respective treatment program. Subject C2 attained his first 75% production accuracy level in connected speech on the 41st session, while Subject M2 did so on her 44th session.

Patterns in [s] Development Exhibited by the Experimental Subjects

Connected Speech. Two essentially different learning patterns emerged in the overall connected speech progressions over time, with regard to minimal production accuracy levels. One pattern was exhibited by Subject C1's progression in which the subject attained his 25% [s] production accuracy level in connected speech fairly early on in his treatment period; a point one quarter of the way through the entire length of his treatment period. This child then spent the remaining three quarters of his treatment period progressing toward his 75% production accuracy level in connected speech. The other pattern was that evidenced in all three of the other subjects' progressions. Subjects M1, M2, and C2 each progressed through at least half of their entire treatment periods before attaining their 25% [s] production accuracy level in connected speech probes. Subject M1 progressed through 62% of his treatment period; Subject M2 progressed through 57%; and Subject C2 progressed through 50% of his treatment period before attaining the 25% production accuracy level. Their learning pattern then, was one which appeared relatively evenly split between the two production accuracy points; that is, they spent approximately half of their treatment period meeting the minimal production accuracy level, and the remaining half attaining the 75% production accuracy level.

Word Probe Performance. The two distinct patterns revealed in the connected speech probes were seen in the experimental subjects' performance on the word probes as well. Subject M1 proceeded through 44 of the 73 sessions required for him to reach 75% production accuracy, before attaining his 25% level of accuracy on the word probe. He therefore, went through 60% of his treatment period to get to this level and required the remaining 40% to achieve 75% accuracy. Subject M2 went through 22 of the 42 sessions needed for her 75% accuracy level, to achieve the 25% level of accuracy. This meant that she proceeded through 52% of her entire treatment period reaching the 25% production accuracy level on the word probe, and required the remaining 48% of the treatment period to attain the 75%

production accuracy level. Subject C2 went through 21 of 42 sessions required to reach the 75% accuracy level, before attaining the 25% production accuracy level in words. This meant that he proceeded through 50% of his treatment period getting to the 25% level of accuracy and spent 50% of his time reaching the 75% production accuracy level.

Subject C1 maintained his relatively early attainment of the 25% production accuracy level in his word probe performance by reaching it on the fifteenth of 61 sessions needed for the 75% production accuracy criterion. This meant that he attained his 25% production accuracy level in the first quarter of his treatment period and required the remaining three quarters of his treatment period to reach his 75% production accuracy level (A table of these relative proportions by subject may be found in Appendix E).

Temporal Relationship Between Single Word Production Accuracy Levels and Spontaneous Connected Speech Production Accuracy Levels

Across all subjects there was strong consistency between production accuracy levels for both word and spontaneous level production tasks. The greatest difference evidenced between the 25% production accuracy level for both words and sentences was five sessions for subject C2. This was followed by a four session difference between the same two probes for subject M2. Subject M1 and Subject C1 attained their respective 25% production accuracy levels on both word and connected speech probes within a single alternation cycle of the two probe types (a two session time difference for Subject M1, and a one session difference for Subject C1). For the 75% production accuracy level the time difference was even less across probe tasks. For both words and connected speech all four experimental subjects reached the 75% production accuracy level on both the word and connected speech probe within one alternation cycle (word and connected speech probes were generally administered in alternating fashion from one session to the next). The maximum number of sessions required to accomplish this was three.

Order of Emergence of Lexical Shapes

Subjects' progress on this topic is described relative to individuals within treatment groups since one of the differences in treatment approaches was that a teaching order of lexical shapes was imposed for those subjects in the sensory motor approach. For both subjects experiencing the sensory-motor approach the order of introduction in treatment of the lexical shapes represented on the probes was: /sV-, -Vs, sCV-/ and /-VCs/. The subjects in the cognitive approach both began with the /sV-/ lexical shape in minimal pair contrasts, and the other lexical shapes were then introduced but not in a formal teaching order.

Subjects in the Sensory Motor Approach

Subject M1. As can be determined from visual inspection of Table 11, this subject's order of emergence of lexical shape followed the order of introduction in treatment, except for /sV-/ which emerged last. This subject exhibited a stable order of emergence of /-Vs/ first and /sCV-/ second for both probes across both levels of production accuracy. Though his lexical shape order of emergence varied after the first two shapes, he exhibited the same order of emergence at the minimal production accuracy level for both word and connected speech probes. He also exhibited another stable order of emergence of lexical shapes at the 75% level of production accuracy. Though he exhibited all lexical shapes on both word and connected speech probes at the 25% level of production accuracy, only three lexical shapes were evidenced at the 75% level of production accuracy.

Subject M2. Subject M2's order of emergence of lexical shapes only corresponded to teaching order at the 75% production accuracy level in connected speech. She did not

Table 11. Lexical Shape Emergence by Subject

M1

	Wd 25%	Wd 75%	Spon 25%	Spon 75%
1.	Vs (14)	Vs (14)	Vs (14)	Vs (46)
2.	sCV (44)	sCV (47)	sCV (46)	sCV (64)
3.	VCs (47)	sV (73)	Vcs (52)	sV (70)
4.	sV (64)	--------	sV (65)	--------

M2

	Wd 25%	Wd 75%	Spon 25%	Spon 75%
1.	Vs (10)	vS (22)	Vs (21)	sV (32)
2.	Sv (22)	Sv (30)	sCV (26)	Vs (41)
3.	VCs (22)	sCV (42)	VCs (26)	sCV (47)
4.	sCV (33)	--------	sV (29)	--------

C1

	Wd 25%	Wd 75%	Spon 25%	Spon 75%
1.	Vs (6)	Vs (15)	Vs (16)	Vs (16)
2.	sCV (33)	sV (50)	VCs (40)	sV (51)
3.	sV (64) VCs (44)	sCV (61)	sCV (43)	--------
4.	--------	--------	sV (46)	--------

C2

	Wd 25%	Wd 75%	Spon 25%	Spon 75%
1.	Vs (14)	Vs (14)	sV (23) Vs (23)	VCs (29)
2.	sV (21) VCs (21)	sV (21) VCs (21)	VCs (26)	sV (35)
3.	sCV (30)	sCV (42)	sCV (41)	Vs (38)
4.	--------	--------	--------	sCV (52)

exhibit any consistency in order of emergence of lexical shape across probe types or production accuracy levels, unlike Subject M1. In fact, this subject was the only one who exhibited any lexical shapes at minimal production accuracy levels on the probes prior to their having been introduced in treatment. She produced the /-VCs/ shape at the minimal production accuracy level across both probe types before it was introduced in treatment; and she produced the /sCV-/ shape at the 25% level of production accuracy on the connected speech probe before doing so on the word probe, and before its introduction in treatment.

Both Subjects M1 and M2 failed to reach the 75% production accuracy level on the /-VCs/ shape on both the word and connected speech probes. The lexical shapes which emerged within a five to ten session period relative to their introduction in treatment were: Subject M1- /-Vs/ (at both production accuracy levels in words, and the 25% accuracy level in connected speech); M2- /-Vs/ (25% accuracy level in words); /sCV-/ 25% accuracy level in words.

<u>Subjects in the Cognitive Approach</u>:

<u>Subject C1</u>. This subject did not develop the /sV-/ lexical shape until after the /-Vs/ shape emerged despite the fact that it was the first one stressed in treatment.

The only order of emergence consistency within this subject's performance was that of the development of the /Vs-/ shape first and the /sV-/ shape second at the 75% production accuracy level across both word and connected speech probes. This subject demonstrated the fewest (two) lexical shapes to emerge at the 75% production accuracy level in connected speech.

Subject C2. This subject also did not develop the /sV-/ lexical shape first except at the 25% production accuracy level for connected speech, when it tied with the /-Vs/ shape for first in order of emergence. Subject C2 exhibited the same order of emergence of lexical shapes on the word probe for both levels of production accuracy. This subject was the only experimental subject to develop all four lexical shapes across both probes and at both accuracy of production levels.

Learning Patterns Relative to Lexical Shape

Patterns in Connected Speech. The word final /Vs/ was the earliest one that all four subjects were able to achieve at the 25% accuracy level, except for subject C2 who achieved the same accuracy level on word initial /sV/ on the same date. Word initial /sV/ for the other three subjects was the last syllable shape to reach the 25% accuracy level in spontaneous utterances. Subject C2 demonstrated the least within subject variability across syllable shapes at this production accuracy level (range of 8 percentage points difference), followed by Subject M2, Subject C1 and then Subject M1.

In contrast to results for all four subjects at the 25% level of production accuracy, there were no group trends at the 75% level relative to syllable shape in spontaneous utterances. Three subjects, M1, C1, and M2, never attained the 75% production accuracy level in /-VCs/ syllable shapes in spontaneous utterances. In addition, subject C1 did not achieve /sCV-/ syllable shapes at this accuracy level either in spontaneous utterances. Subject C2 was the only subject to attain the 75% production accuracy level in all syllable shapes in spontaneous utterances by the time he reached terminal criterion level.

Patterns in Words. At the 25% accuracy of production level in words, as with their performance on the spontaneous utterances at the same level of accuracy, the group once again demonstrated the word final /-Vs/ as the earliest one across all subjects to be attained at the 25% accuracy level. It should be noted also that all syllable shapes across all four subjects were produced at the 25% level of accuracy in words prior to the same level in spontaneous utterances.

At the 75% level of production accuracy in words, contrary to the earlier comparison across production levels at the spontaneous utterance level, the word final /-Vs/ was the first syllable shape across all four subjects to be attained at this level, as it was at the 25% level of accuracy. Subject C2 however, achieved the 75% level of accuracy of production in word initial /sV-/ at the same time as he did /-Vs/. Once again, as in spontaneous utterances, subject C2 was the only one to attain the 75% production accuracy level across all syllable shapes. Subjects M1, C1, and M2 never attained the 75% level in /-VCs/ shapes.

Emergence of /sV-/ and /sCV-/ Lexical Shapes

Subject M1. Figures 7 and 8 represent Subject M1's development of the /sV-/ and /sCV-/ lexical shapes, respectively. Beginning with Figure 8, it can be seen that the earliest point at which this subject produced any word initial [s]'s occurred on the 40th session on his [sCV-] word probe productions. Connected speech level production of these structures occurred for the first time on the 46th session connected speech probe. Subject M1's performance on the word level [sCV-] items was characterized by a sharp rise to 90% accuracy. His connected speech performance on the same structure came later and did not rise quite as sharply.

Figure 7 illustrates Subject M1's [sV-] development

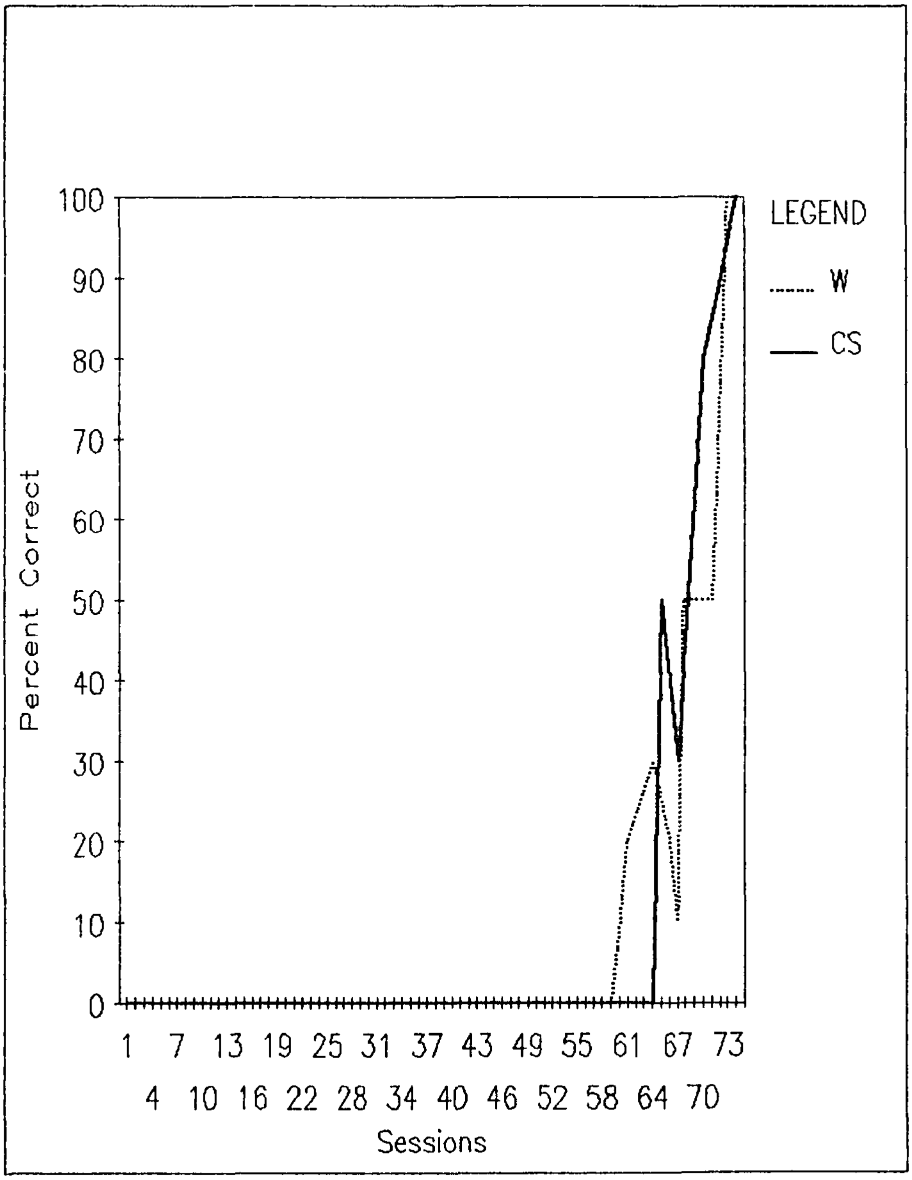


Figure 7. Subject M1's development of the /sV-/ lexical shape in single words and connected speech over time.

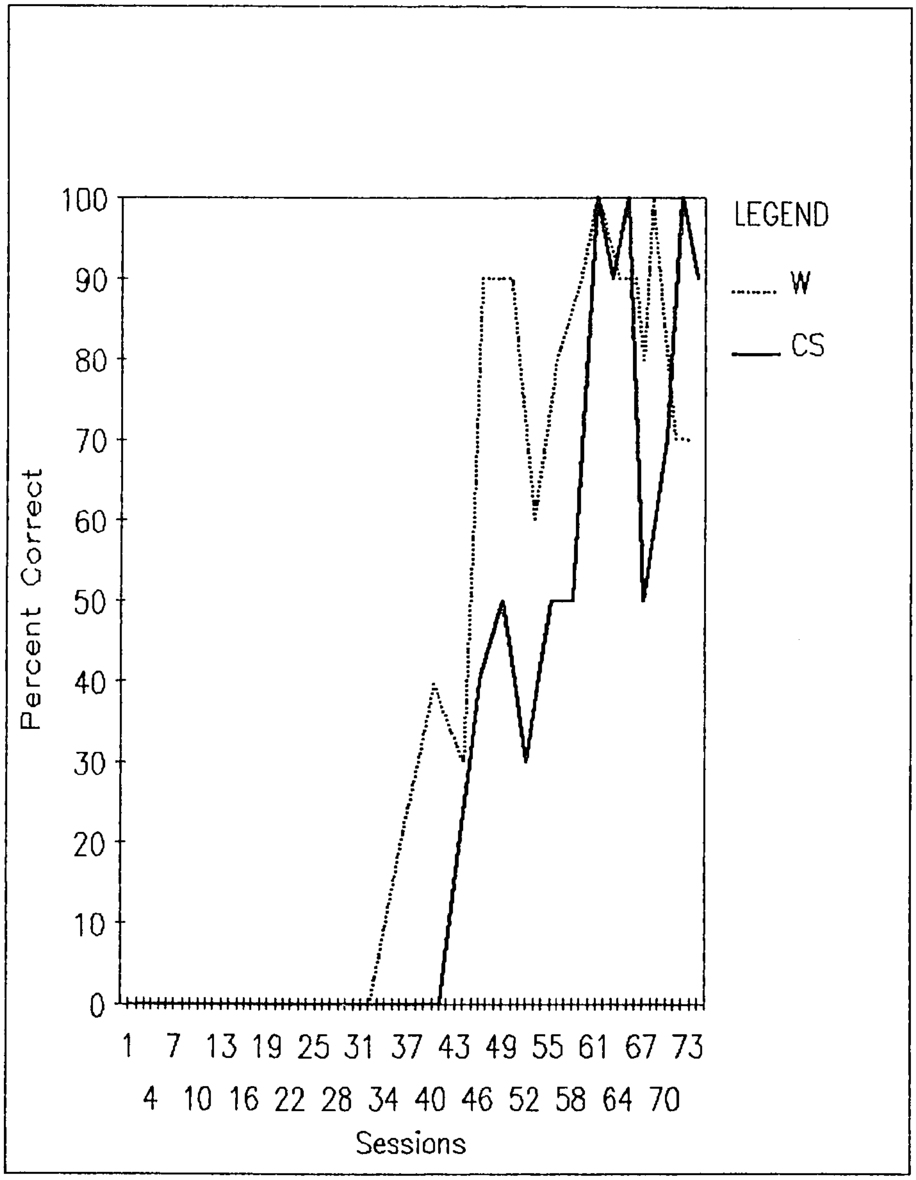


Figure 8. Subject M1's development of the /sCV-/ lexical shape in single words and connected speech over time.

which did not begin until his 61st session word probe. This structure appeared on the 65th session probe in connected speech. At both the word and connected speech levels, this subject's [sV-] productions improved from a zero baseline to 100% accuracy by the 73rd and 74th sessions, respectively, resulting in Subject M1 reaching final criterion on the 74th session.

Subject C1. Subject C1's development of the /sV-/ and /sCV-/ lexical shapes are displayed in Figures 9 and 10 respectively. As can be seen from the graphs, this subject exhibited no word initial [s] productions until the 27th session for the /sCV-/ structure in single words and the 44th session for /sV-/ in single words. In connected speech, Subject C1 began producing [sCV-] on the 32nd session probe, and [sV-] structures on the 46th session probe. It can be seen in Figure 10 that Subject C1 improved his [sCV-] productions in a gradual and uneven progression with both word and connected speech productions experiencing a significant downward trend just prior to a final two session upswing. Subject C2's [sV-] productions in contrast, began considerably later than his [sCV-] productions, but the progression for [sV-] productions in words rose sharply from 50% to 100% accuracy within four productions appeared shortly after word level productions and also experienced a sharp initial rise with one significant downward trend followed immediately by a sharp

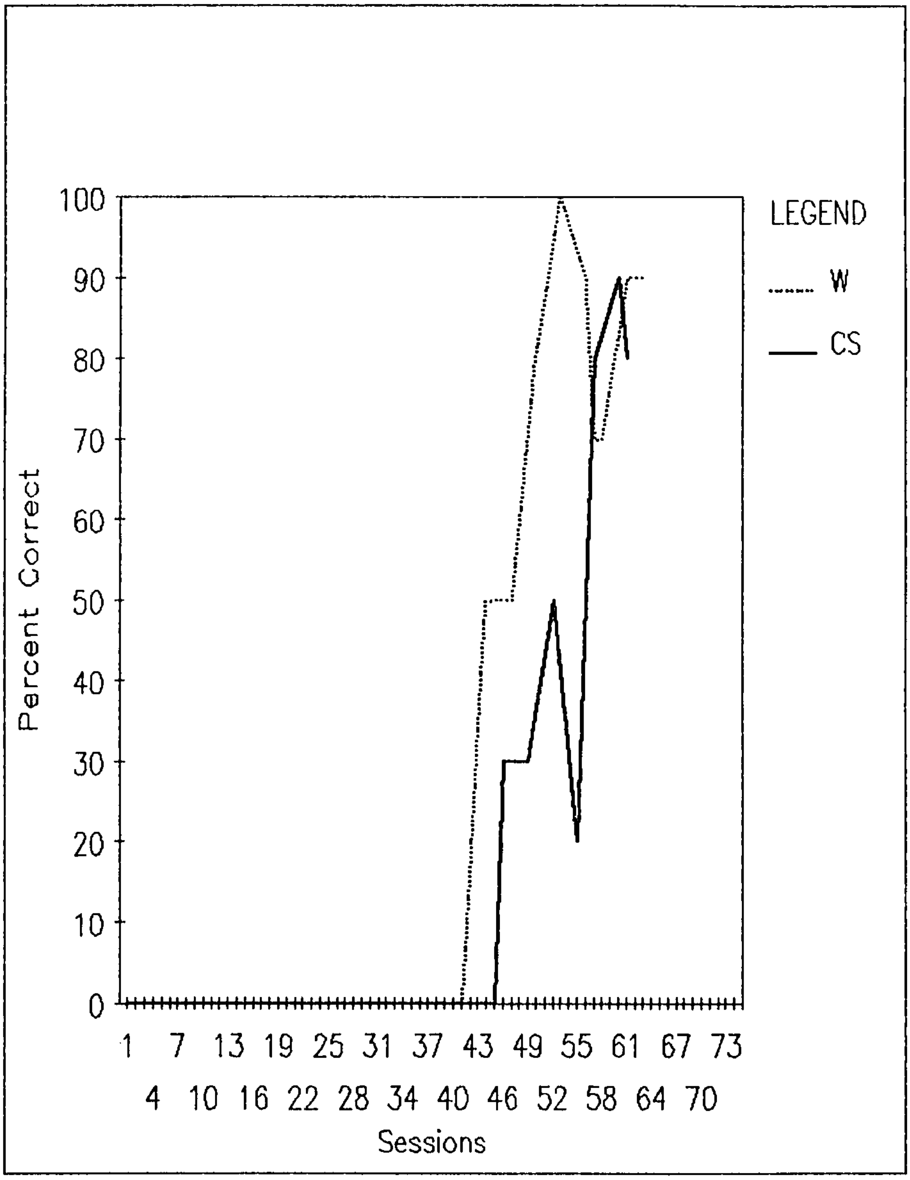


Figure 9. Subject C1's development of the /sV-/ lexical shape in single words and connected speech over time.

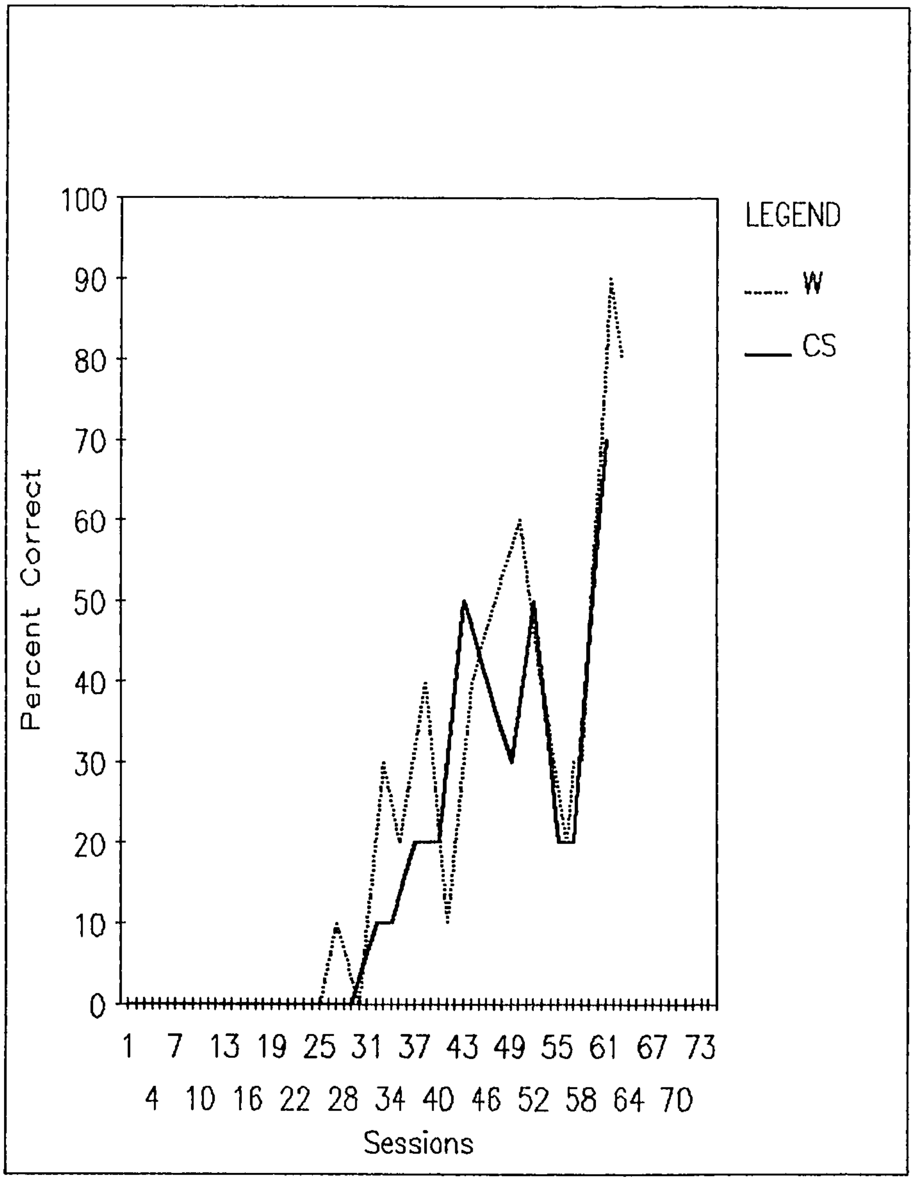


Figure 10. Subject C1's development of the /sCV-/ lexical shape in single words and connected speech over tima.

rise to 80% accuracy of production prior to the end of treatment.

Both Subjects M1 and C1 exhibited relatively late emergence of the word initial structures, particularly the [sV-] structures. Despite their late emergence, however, these structures developed rapidly for both subjects.

Subject M2. Figures 11 and 12 illustrate Subject M2's [sV-] and [sCV-] development, respectively. Subject M2's [sV-] and [sCV-] development both began in single words at approximately the same time, and relatively early into her treatment period, between the 10th and 16th treatment sessions respectively. Subject M2's [sV-] structures appeared in connected speech on the 26th session probe, while her [sCV-] structures appeared on the 23rd probe session. This subject's single word performance on [sV-] structures was marked by extreme variability until her last three sessions, while her connected speech performance on the same structure revealed just the opposite, a sharp incline up to a stable 90% accuracy level. M2's performance on [sCV-] in both word and connected speech performance was characterized by variability followed by steady upward trends on the last three sessions to criterion.

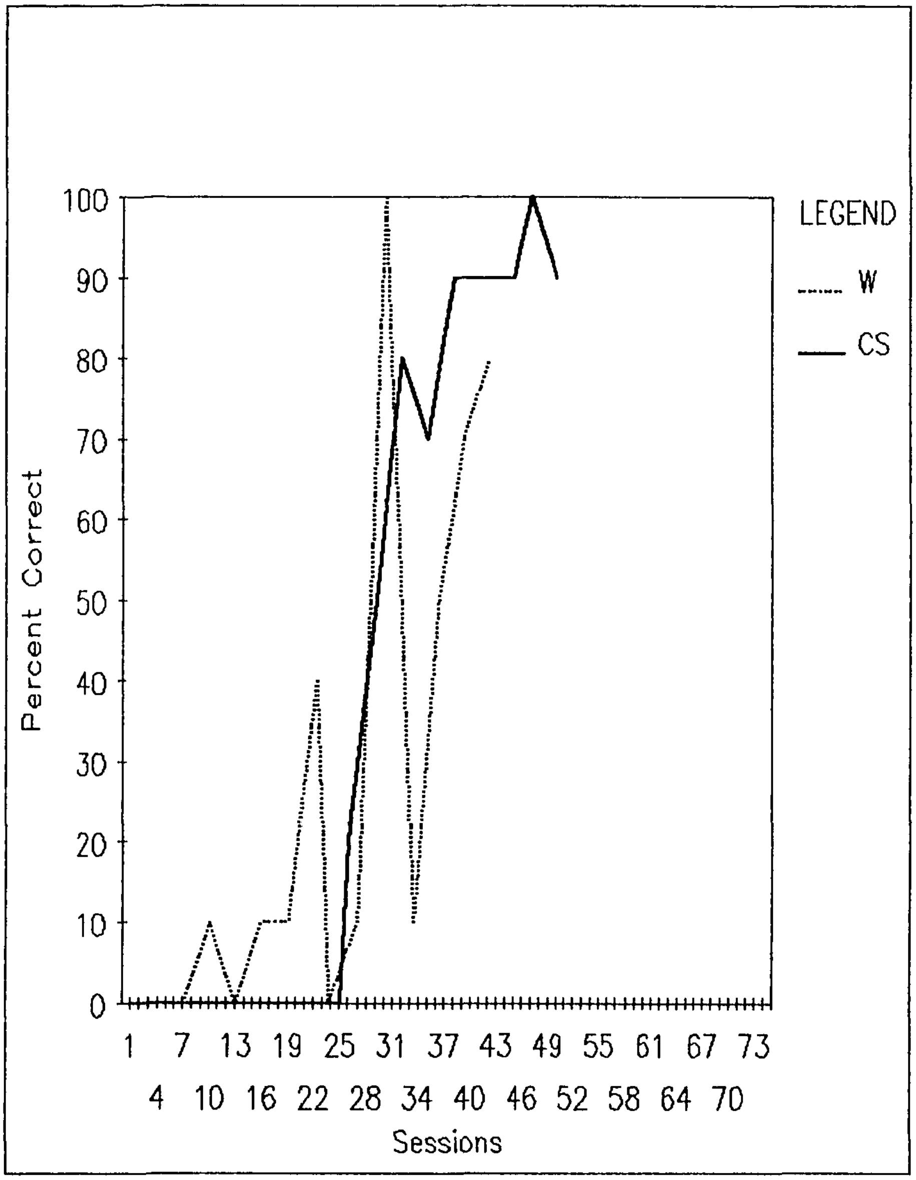


Figure 11. Subject M2's development of the /sV-/ lexical shape in single words and connected speech over time.

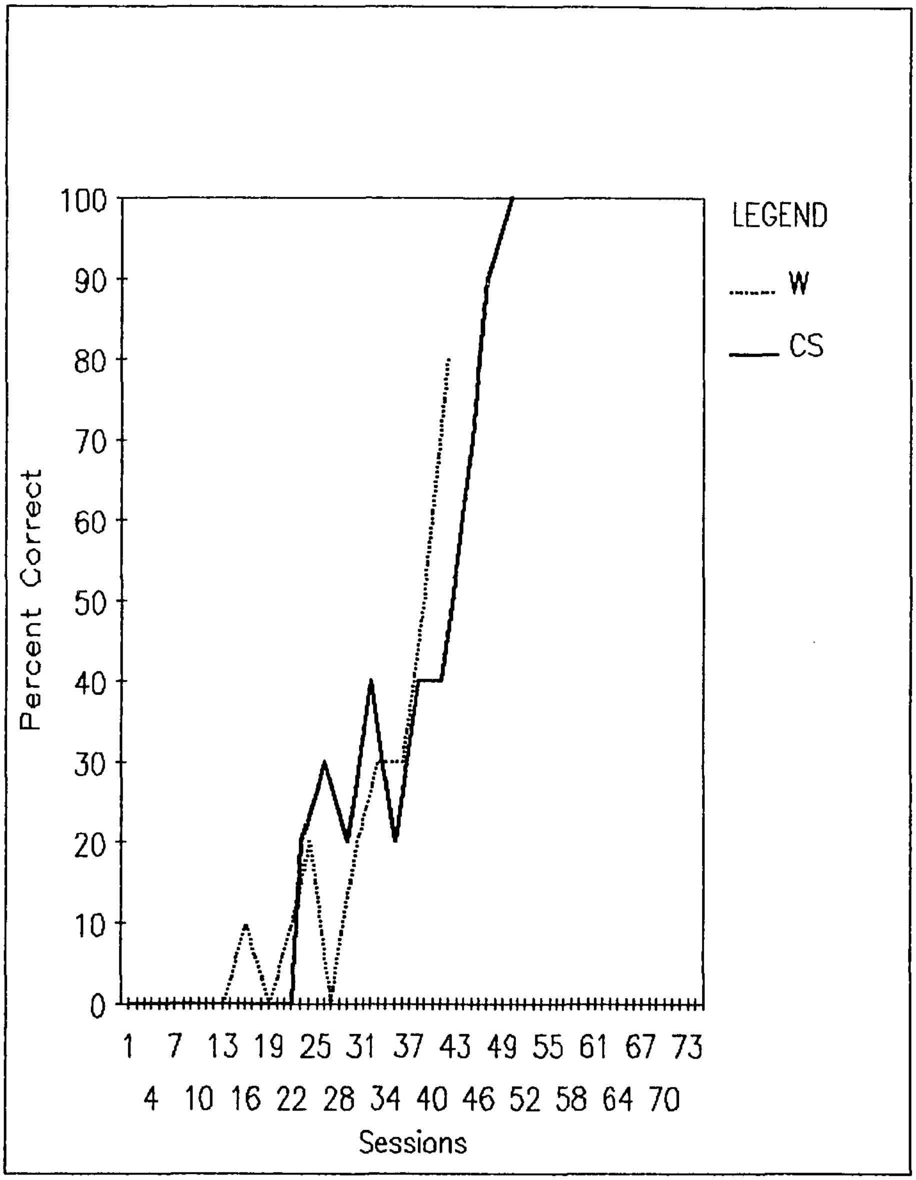


Figure 12. Subject M2's development of the /sCV-/ lexical shape in single words and connected speech over time.

Subject C2. Subject C2's [sV-] development is depicted in Figure 13 while his [sCV-] development is depicted in Figure 14. His [sV-] and [sCV-] development in words began on the 21st session, except for a one time appearance of one [sCV-] item earlier. Subject C2's [sV-] development in words however, was dramatic in that he began [sV-] production in words at the 80% accuracy level and on the next probe attained 100% accuracy. His connected speech performance on [sV-] was characterized by a sharp rise which leveled off for several sessions at a 50% accuracy of production level before a sharp rise to 100% accuracy immediately after. Both word and connected speech performance on [sV-] lexical shapes were variable, but above the 70% accuracy level for the last sessions.

Subject C2's [sCV-] development in connected speech began on the probe on the 32nd session, thereby exhibiting a delay relative to emergence at the word level. Basically, connected speech development for this lexical shape shadowed that of his progression in single words, except that connected speech development was less variable overall. On the 45th and 47th sessions production performance for word and connected speech rose to the 50% production accuracy levels, respectively and continued to rise to 80% production accuracy, with word level production experiencing a slight downward trend on the last probe session.

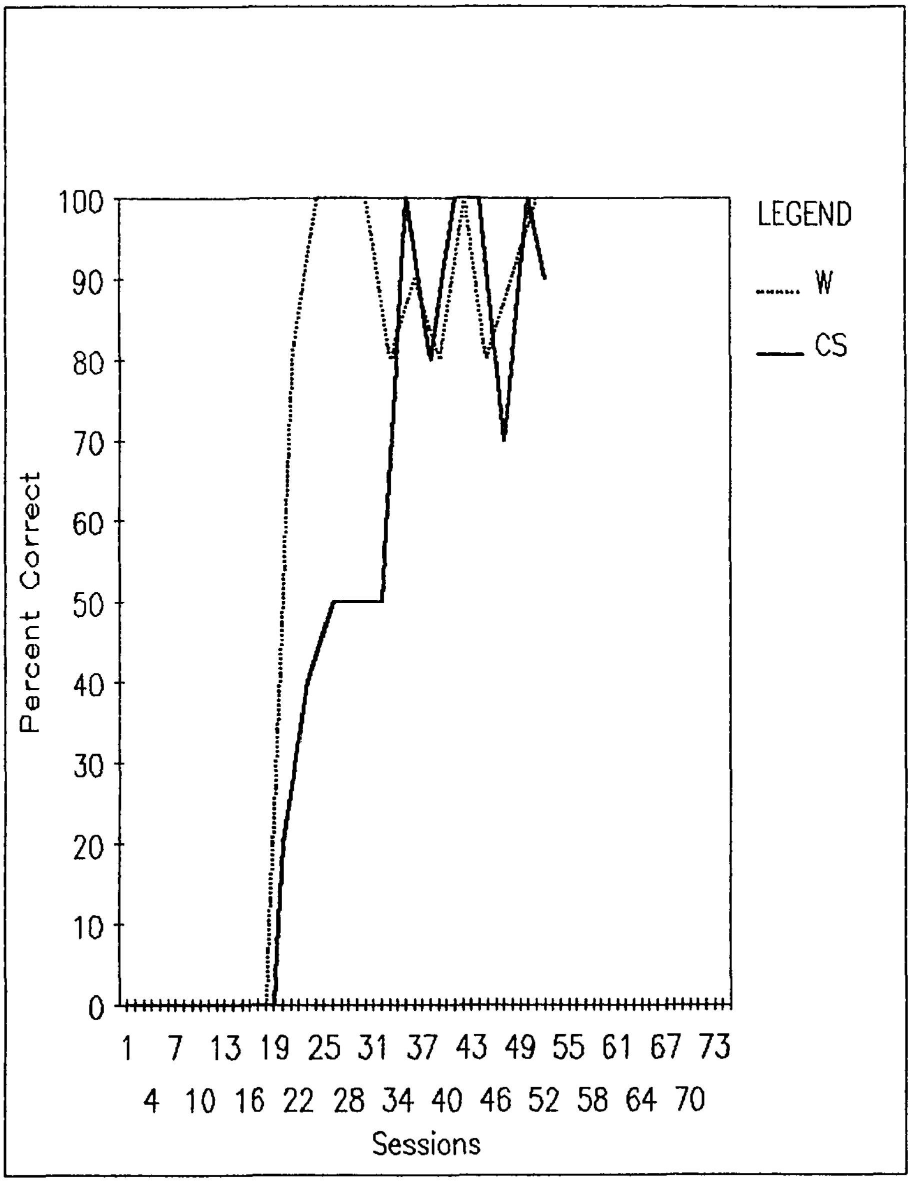


Figure 13. Subject C2's development of the /sV-/ lexical shape in single words and connected speech over time.

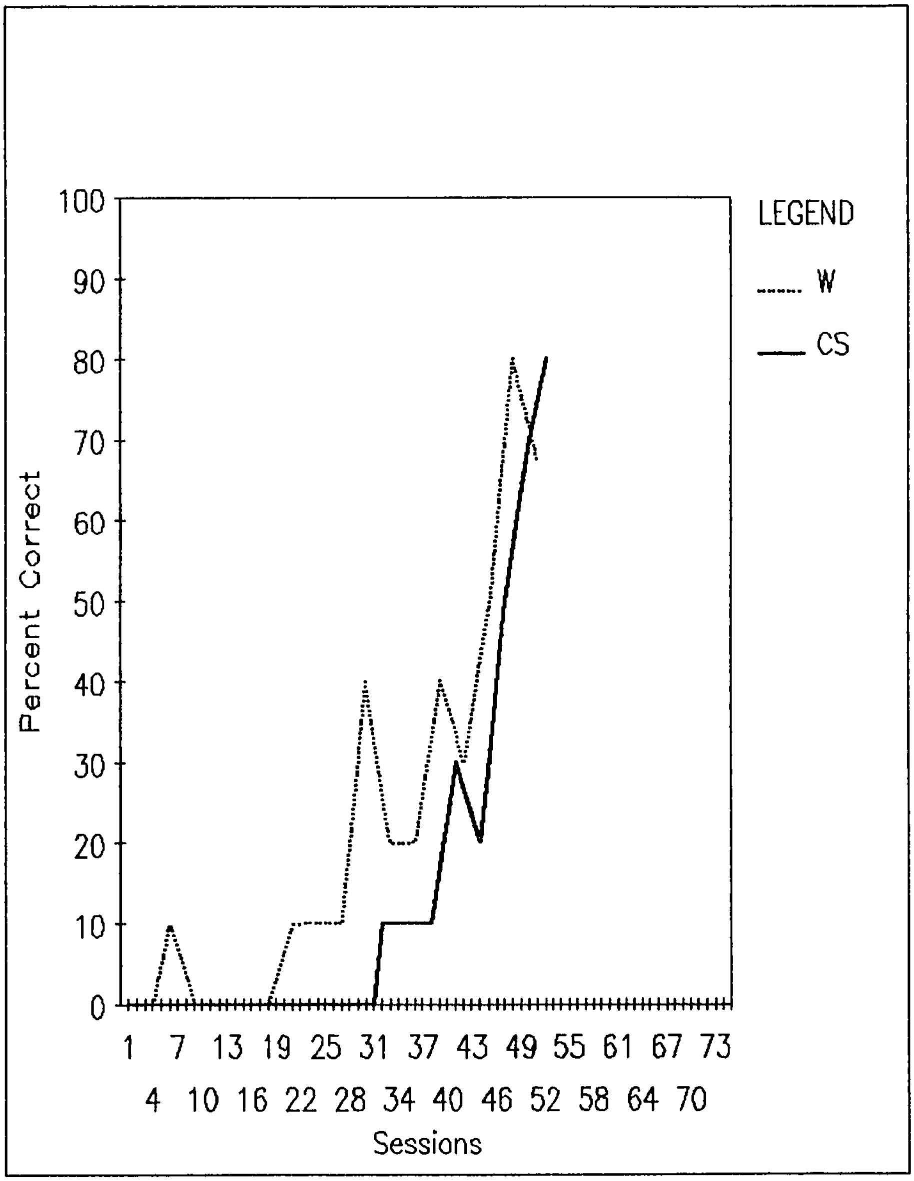


Figure 14. Subject C2's development of the /sCV-/ lexical shape in single words and connected speech over time.

<u>Average Number of Responses Per Session By Treatment Type</u>

A comparison of the average number of responses elicited per session by each subject according to treatment approach revealed the following: (a) Subject M1 produced 157 responses (b) Subject C1 produced 35 (c) Subject M2 produced 167 (d) and Subject C2 produced 29. In order to obtain these averages, the investigator added the number of [s] related responses which occurred on every fifth session for each subject. Each subject's total was then divided by the number of sessions used to obtain the total resulting in the estimated average number of [s] related responses per subject.

Within the first pair, Subject M1 averaged four times as many responses as Subject C1. In the second treatment pair, Subject M2 averaged five times as many responses as her match C2. This ratio of responses relative to treatment type is consistent with the assumptions of the respective treatment types, and was expected. The results however, of the relative rate of learning by the cognitive approach subjects compared to the motor approach subjects were completly unexpected under the assumptions of motor theory. This finding will be discussed further in Chapter Four.

In summary a number of findings have been presented relative to the first research question addressed in this study. First, with regard to differential treatment effects on the number of sessions required to attain a given result, it was reported that Subjects C1 and M2 reached terminal criterion prior to their respective matches. In the case of the first pair there was a clear difference of thirteen sessions in length of treatment period to terminal criterion between the two subjects. In the case of the second pair, there were six sessions difference; however; terminal criterion requirements specified that a subject had to attain a level of 75% production accuracy in two consecutive complete connected speech probes. Subject C2 attained a 75% level on the 41st session, followed by two consecutive 73% scores, then an 88% and 90% accuracy of production score at which time he achieved the "true" terminal criterion. In chapter four, the implications of this finding will be further discussed. Second, a number of "learning patterns" were revealed in the subject's respective performances through treatment. One pattern described was in reference to the minimal production accuracy level (25% correct) exhibited by the four subjects. Three subjects, Subject M1, Subject M2, and Subject C2 all reached their respective minimal production accuracy levels at points approximately half way through the length of their treatment programs. Subject C1 in contrast attained his minimal production accuracy level at a relatively early point approximately one quarter of the way into his treatment period. Another learning pattern described in the results presented in this section had to do with the overall time period required for a subject to attain his final criterion. Subjects M1 and C1 exhibited relatively protracted learning curves when compared to those exhibited by Subjects M2 and C2. A third learning pattern described was that of the temporal relationship between the attainment of minimal and maximum production accuracy levels from words to spontaneous connected speech. A strong consistency (not more than two complete alternations of word probe to connected speech probe) was noted between production accuracy levels for [s] productions in both single word and spontaneous connected speech measures for all four experimental subjects.

Lexical Shape emergence was discussed individually, relative to treatment effects and across subjects. A number of findings were reported: first, teaching order effects on lexical shape emergence were evidenced in varying degrees in both subjects in the sensory motor approach; second, Subjects M1 and C1 exhibited similar protracted learning patterns on emergence of /sV-/ lexical shapes; third, all subjects exhibited the emergence of /-Vs/ lexical shapes as the first shape to reach the minimal and maximum accuracy of production levels on single word probes, despite the fact that all subjects experience the /sV-/ shape first in treatment; all four also exhibited this lexical shape first at the minimal accuracy of production level in connected speech, though Subject C2 exhibited /sV-/ at that production accuracy level at that time as well; fourth, all subjects exhibited all four lexical shapes at the 25% production accuracy level in word performance, prior to attaining the same minimal production accuracy level in connected spontaneous speech.

Treatment types differed greatly in the average number of [s] related responses per session, with subjects in the sensory motor approach experiencing between 4-6 times as many responses per session than those subjects in the cognitive treatment approach.

COMPARISON OF SENSORY MOTOR ABILITIES BETWEEN THE NORMAL SUBJECTS AND THE MISARTICULATING SUBJECTS

The second major question addressed in this investigation was whether or not pre-school unintelligible misarticulators who stop for [s] exhibit sensory-motor differences when compared to their normal peers. Of interest also in this study was whether or not following the completion of treatment, subjects in the sensory motor articulation treatment approach demonstrated greater similarity to the normal subjects in terms of [s] duration measures than did the subjects in the cognitive approach. Another aspect of the investigation involving duration measures was whether or not the experimental subject's normally intended stops were different from the stops classified as "errors" when they occurred in place of [s].

The sensory motor measures utilized for the purposes of this study involved [s] duration and the interval between vowels preceding and following /s/ in the intervocalic phonetic environments in which /s/ occurred. The [s] duration measures involved both intervocalic /s/ singletons and /s/ clusters and were conducted on both normal and experimental subjects for comparison purposes. A primary purpose of the vowel-to-vowel duration measure was that it allowed for duration measurements of the pre-treatment productions of the experimental subjects on normally intended stops. The normally intended stop duration mean for each experimental subject was then compared to his own mean durations of the stops which occurred when [s] should have occurred.

Results will be presented relative to individual subject performance first, and will be followed by results relative to performance by group. The [s] duration measures will be discussed and will be followed by the presentation of the vowel to vowel measures. The three measurement points are referred to as pre-treatment, mid-treatment, and post-treatment for ease of discussion. "Mid-treatment" refers to that point in time for a given subject at which he is producing [s] with approximately 50%

production accuracy on the specific phonetic structure under discussion. The "post-treatment" point likewise reflects the point of terminal criterion.

Measures of [s] Duration

Individual Subject Performance on [s] Duration Measures

Figure 15 reveals the mean [s] duration in intervocalic /s/ singleton environments and in /s/ cluster environments for each normal subject. Figure 16 reveals each individual experimental subject's respective changes in mean singleton [s] duration from the mid-treatment measurement point to the post treatment point. Figure 17 provides the same information relative to /s/ clusters. Table 12 provides the mean, standard deviation, and coefficient of variability information by subject, for each phonetic context, at each point in time.

Subject M1 exhibited the longest mean singleton [s] durations at the mid-treatment point and the post-treatment point of any of the experimental subjects. This subject increased his mean [s] singleton duration from the mid treatment point (345 msec) to the post-treatment point (424 msec) though he demonstrated a decrease in variability over time. It should be noted that this subject's [s] singleton productions at the mid-treatment measuring point contained

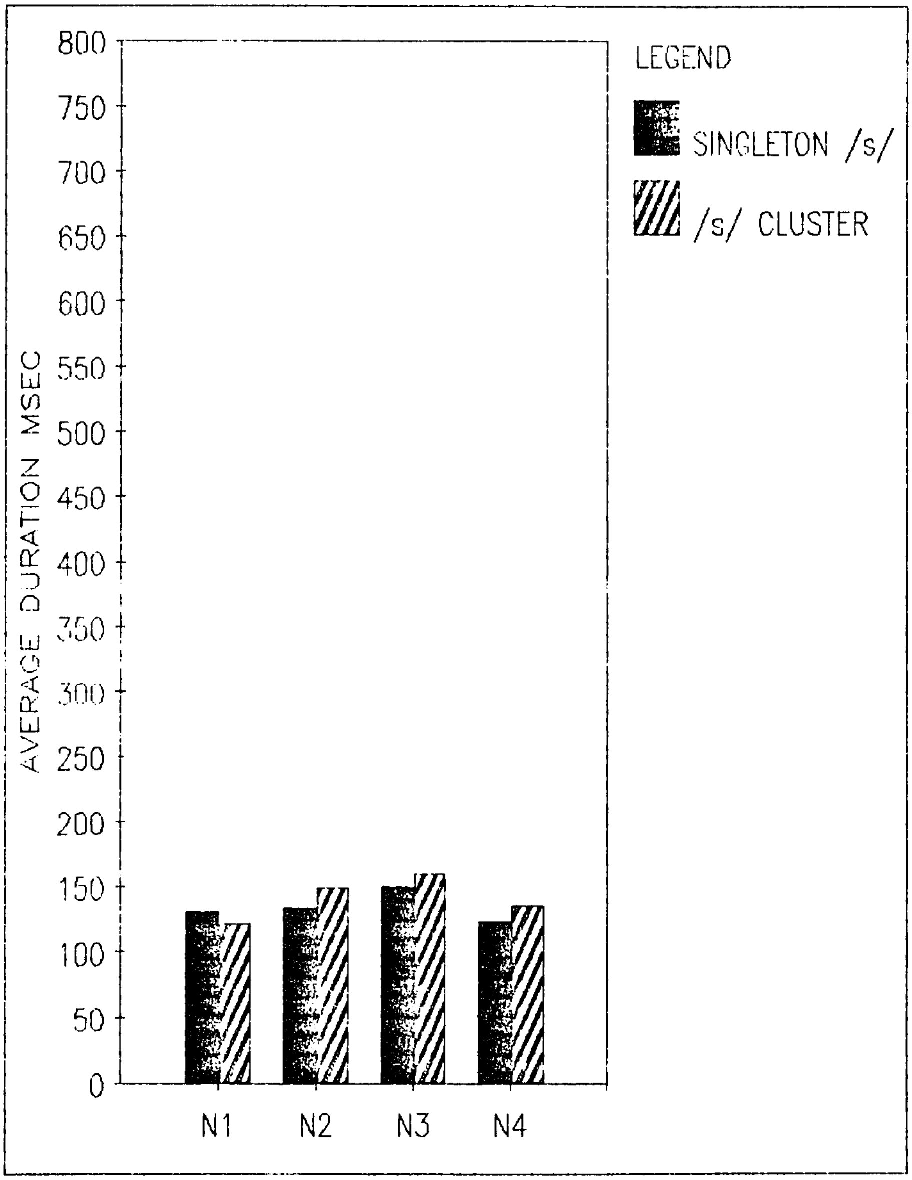


Figure 15. Mean [s] duration in intervocalic /s/ singleton environments and in /s/ cluster environments for each normal subject.

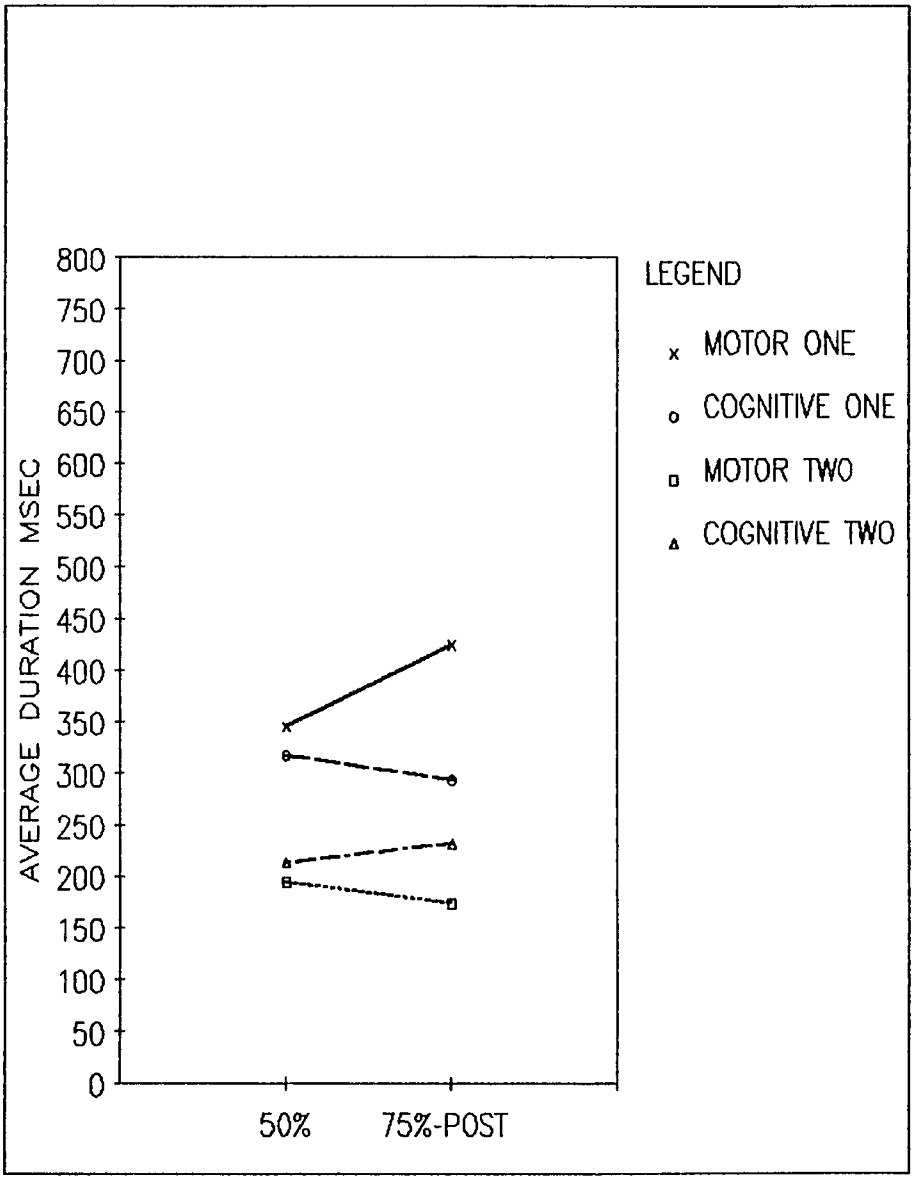


Figure 16. Changes in mean [s] duration relative to intervocalic singleton /s/ by experimental subject from the mid-treatment point to the post-treatment measurement point.

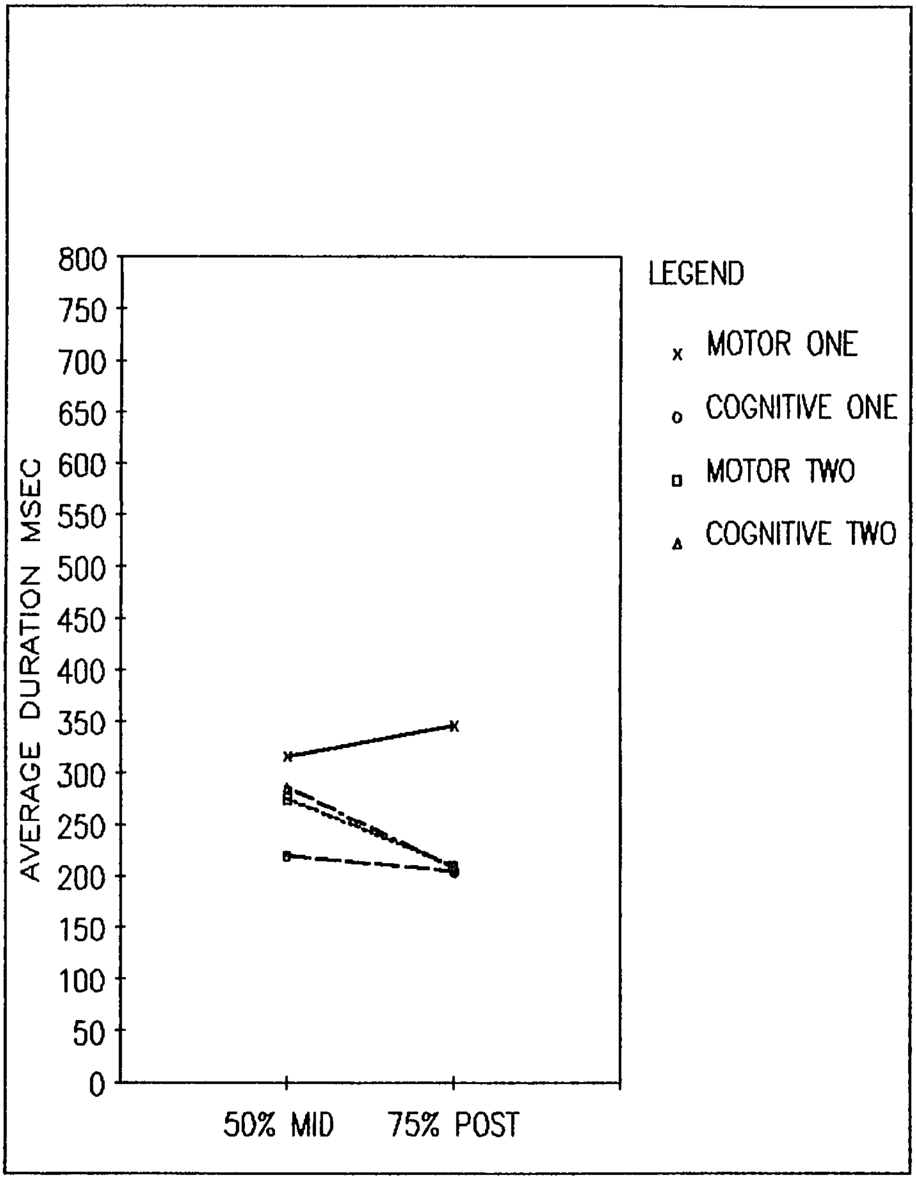


Figure 17. Changes in mean [s] duration relative to intervocalic /s/ clusters by experimental subject from the mid-treatment measure to the post-treatment measurement point.

Table 12. Means, standard deviations (in parentheses) and coefficients of variation (%) of [s] duration on the /s/ singleton and /s/ cluster speech probe items produced by experimental subjects at mid-treatment and post-treatment

	SUBJECT			
TREATMENT POINT/ PHONETIC CONTEXT	M1	C1	M2	C2
Mid- /s/ singleton	345 (128) 37% n=7*	317 (68) 22% n=10	194 (37) 19% n=10	213 (56) 26% n=10
Mid- /s/ cluster	316 (379) 120% n=5	219 (40) 18% n=5	275 (128) 47% n=5	286 (92) 32% n=4*
Post- /s/ singleton	424 (116) 28% n=7*	293 (35) 12% n=9*	173 (25) 14% n=9*	232 (53) 23% n=9*
Post- /s/ cluster	346 (198) 57% n=5	204 (42) 20% n=5	209 (55) 27% n=5	207 (44) 21% n=5

NOTE. * At each measurement point, ten /s/ singleton items and five /s/ cluster items were submitted per child; numbers show differences because spectrographic representation was insufficient for analysis.

some stops. Four of his productions contained [s] clusters in place of [s] singletons. This would appear to account for the similarity between the mean durations for his [s] singletons and his [s] clusters at the mid-point measure. At the post-treatment measuring point, the two means were different with the mean duration for clusters being shorter than for singletons.

Subject M2, on the contrary, decreased her mean duration and variability over time. This subject's mean durations were the shortest at both mid-treatment (194 msec) and post-treatment (173 msec) of any of the other experimental subject's. Subject M2 was the only experimental subject who exhibited longer mean durations for the [s] cluster environments than for the [s] singleton environments at the post-treatment measurement point. She had demonstrated the same relative mean duration pattern at the mid-treatment measurement point as well.

Subject C1 demonstrated the second longest [s] singleton mean durations from both mid-treatment (317 msec) to post-treatment (293 msec) measurement points, and decreased mean duration over time. At the mid-treatment point this subject produced an [h] between the word initial [s] and the succeeding vowel in [s] singleton environments. This subject also reduced variability about his mean by half from the mid-treatment point to the post treatment point on /s/ singletons. This subject's /s/ cluster durations and relative variability were similiar from mid- to post-treatment.

Subject C2 had the third longest mean [s] singleton durations over time, 213 msec at mid-treatment and 232 msec at post-treatment, and this subject also increased his mean duration over time. Subject C2's variability about his mean remained essentially the same from mid to post treatment for the [s] singleton environments. This subject at the mid-treatment point exhibited a longer mean duration for [s] cluster environments than for [s] singletons. He reversed this pattern at the post-treatment point, and reduced variability as well.

Rank Ordering of Individual Subjects According to Average [s] Durations

Non-statistical comparisons of the duration data were made and a discussion of those comparisons follows. The average [s] durations for subjects within the experimental group at both the mid-treatment measuring point and the post-treatment measuring point were ranked from highest to lowest and compared on the basis of visual inspection to the same type of ranking within the normal subject group. There was no overlap between the two groups. This comparison involved both the intervocalic singleton [s] duration comparisons and then the intervocalic clustered [s] duration comparisons.

First, the investigator rank ordered the experimental subject's mean singleton [s] durations at their respective mid-points in treatment. This set of means was compared to the rank ordered singleton [s] duration means of normal group. The means, standard deviations, and coefficients of variation for the normal subjects' [s] durations are provided in Table 13. The experimental subjects' means from highest to lowest were: 345, 317, 213, and 194 msec. The normal subjects' means ranked from highest to lowest were: 151, 135, 132, and 124 msec. There was no overlap in means between these two sets. Subject rankings following that order were as follows for the experimental subjects: 8-M1, 7-C1, 6-C2, and 5-M2. The normal subject rankings following their respective order was: 4-N3, 3-N2, 2-N1, and 1-N4.

Next, the investigator rank ordered the experimental subjects' mean durations on their post treatment measures with the ranking of the normal subjects' means. This time the experimental subjects' means were ranked as follows from highest to lowest: 424, 293, 232, and 173 msec. Once again there was no overlap between the means in the experimental subject group and those of the normals. Experimental subject rankings by subject were the same as at the mid-treatment measuring point. These relative differences among the experimental subjects are clearly visible in Figure 16.

The second set of comparisons involved the comparison once again of the experimental subjects' respective means at their mid- and post treatment measurement points with the normal subjects' means, but this time the comparison

Table 13. Means, standard deviations (in parentheses) and coefficients of variation (%) on [s] duration on /s/ singleton and /s/ cluster speech probe items produced by normal subjects

	SUBJECT			
CONTEXT	#1	#2	#3	#4
/s/ singleton	132 (26) 20% n=10	135 (39) 29% n=10	151 (63) 42% n=10	124 (18) 14% n=10
/s/ cluster	123 (18) 15% n=5	151 (32) 22% n=5	161 (31) 19% n=5	137 (21) 17% n=5

involved /s/ clusters. The mid- treatment ranking for the experimental subjects from highest to lowest was: 8-316, 7-286, 6-275, and 5-219 msec. The normal subject /s/ cluster means were ranked from highest to lowest as follows: 4-161, 3-151, 2-137, and 1-123 msec. There was no overlap between these two sets of means. The normal subjects, N3 and N2, retained their highest and second highest within group ranking respectively, relative to their earlier order on the singleton [s] duration measures. The experimental subject rankings by subject were from highest to lowest: M1, C2, M2, and C1. This within group order differed from that in the singleton [s] duration rank ordering.

The last comparison was that of the experimental subjects' cluster [s] duration means ranked at the post-treatment measurement point. This time the experimental subject's means ranked from highest to lowest were: 346, 209, 207, and 204 msec. Once again there was no overlap between the set of experimental subjects' means and that of the normal group. The ranking by subject in the experimental group from highest to lowest on this last set was: M1, M2, C2, and C1. Subjects M1 and C1 maintained their respective first and last places while the subjects in the second treatment pair switched on this last comparison. The means of the last three subjects were extremely close in this last ranking making their relative positions less certain than in their other rankings. This is represented in Figure 17. An additional procedure involving each subject group was conducted for further comparison of the two groups. The individual subject rankings for the experimental group were added together and then divided by the number of subjects to obtain an average ranking. The same was done on the rankings of the normal subjects. This procedure was carried out for four different group mean ranking comparisons: the mid-treatment [s] singleton rankings; the post-treatment [s] singleton rankings; and the [s] cluster mid- and post treatment rankings, respectively. For each of those four comparisons, the experimental subjects consistently maintained the highest rankings of 8, 7, 6, and 5, since they had the longest [s] durations. The normal subjects consistently held the lower four rankings of 4, 3, 2, and 1. Therefore, the average rank for the experimental group was 6.5 and the normal group average rank was 2.5 for each of the four comparisons.

The within group ranking of the experimental subjects was the same from the mid-treatment to the post-treatment measurement points on the average intervocalic singleton [s] duration means for each. The same experimental subject, M1, consistently exhibited the highest mean [s] duration means across all rankings involving both singleton and clustered [s] duration measures. The other three subjects shifted their relative positions in the ordering of means for the clustered [s] durations relative to singleton durations. Subject C1 maintained a ranking of second highest at both mid- and post- treatment points in the singleton [s] durations and ranked lowest at both points for the clustered [s] durations.

Comparisons of relative individual variability between the individual experimental subjects and the individual normal subjects were also made. The experimental subject's respective coefficients of variation were compared to those of the normal subjects. The normal subject's relative intrasubject variability for /s/ singletons ranged from 14-42% (Table 13). All four of the experimental subjects exhibited similiar relative variability to the normal subjects at both mid- and post-treatment. Additionally, each reduced variability from mid- to post-treatment.

Individual variability comparisons on [s] cluster durations were made next. It can be seen from examining the data in Tables 12 and 13 that three of the experimental subjects exceeded the normal subjects' relative variability range at mid-treatment. Three experimental subjects also reduced their respective variability at the post-treatment measure at which time two exhibited similiar relative variability to the normal subjects.

A number of findings suggest the presence of sensory motor differences between the normal and experimental groups. First, there was no overlap between the two groups on any of the comparisons involving mean [s] durations. Comparison of average ranking for each group revealed a difference of 4 which was stable across all four different comparisons. Relative intrasubject variability was different between the two groups at mid-treatment for /s/ clusters. Additionally, the stable rankings of the experimental group on the singleton [s] duration measures suggests that at least for that measure the children within the experimental group exhibited some individual differences within their grouping.

[s] Duration Comparisons Between Normal and Experimental Subject Groups

A comparison of the normal subjects' singleton [s] duration group mean and standard deviation with that of the experimental subjects at their mid-treatment measurement point was made. The experimental subjects' group mean of 267 msec did not overlap or fall within one standard deviation of the normal group mean of 136 msec (standard deviation of 11 msec). In fact, the experimental group's mean duration exceeded that of the normal group's by 120 msec suggesting no apparent similarity between the two means.

Since the experimental group's post-treatment mean of 281 msec exceeded their own mid-treatment mean, there was even less similarity between the experimental subjects' and the normal subjects' respective group means in this last comparison. These results are consistent with the earlier comparison of the rank ordering of individuals within and across groups for singleton [s] duration.

Clustered [s] duration comparisons using group means and standard deviations were made next. The experimental group's average [s] cluster duration at the mid-treatment point of 274 msec was compared to the normal group's mean of 143 (standard deviation of 17) and indicated no overlap. In the last comparison, the experimental subjects' post-treatment average of 242 msec was not within one standard deviation of the normal group average duration. There was no noticeable overlap found in this comparison.

The experimental subjects as a group reflected greater relative variability in their mean [s] duration measures on singleton [s] productions at both their mid- and post-treatment points than the normal subjects. For example, the normal group's coefficient of variation for [s] duration in singletons was 8% while the experimental group's was 28% at the mid- treatment point and 38% at the post-treatment point. However, for [s] cluster duration relative variability, the normal group's coefficient of variability was 12% and the experimental subjects' coefficient of variablity at mid-treatment was 15%, indicating that the two groups were similiar on this measure. In contrast, at post-treatment the experimental group's relative variability was 29% indicating that the two groups differed at this point on this measure.

Comparison of Sensory Motor Subjects' Performance with That of the Subjects in the Cognitive Approach

The two individuals who experienced the sensory motor approach in this study represented the two extremes of the experimental subjects with regard to their respective mean durations of [s] singletons and [s] clusters. Visual inspection of Figure 16 reveals that Subject M1 at both mid-treatment and post-treatment exhibited the greatest mean durations for singleton [s]. Subject M2 in contrast exhibited the mean duration in singleton [s] which most closely approximated that of the normals at both the mid-treatment and post-treatment points. In terms of change over time in mean duration for singleton [s] productions, Subject M2 did improve in terms of reducing her mean [s] duration, making it conform more with that of the normal group. However, one other subject, Subject C1 also demonstrated improvement relative to a reduced mean [s] duration from mid-treatment to post-treatment measurement points. It is clear from Table 12 and Figure 17 that Subject M1 and Subject C2 each demonstrated increased mean [s] duration from mid-treatment to post-treatment measurement points. A comparison of [s] duration change over time according to treatment type reveals mixed results.

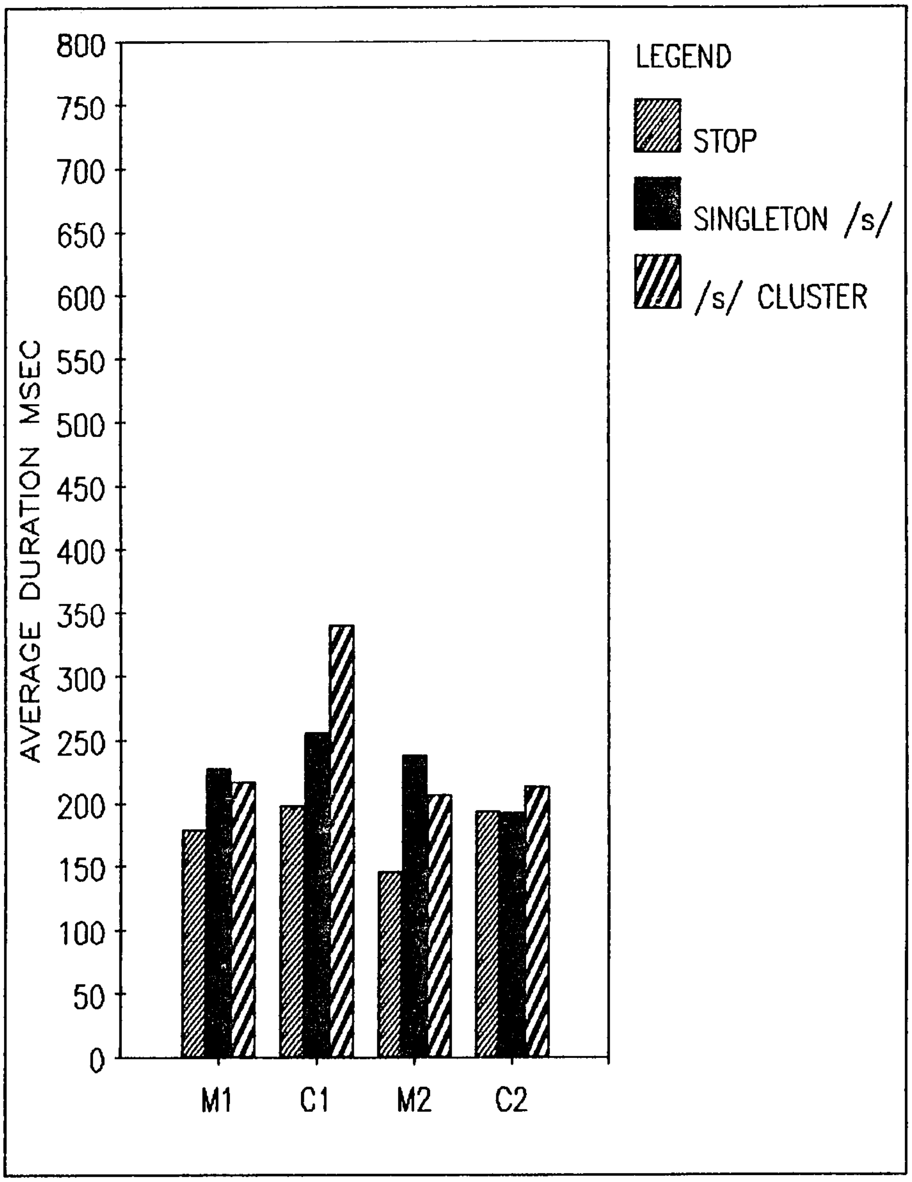
To summarize, visual inspection of the [s] data as well as the comparisons just described confirmed several trends relative to individual subject performance and performance by group. First, none of the individual experimental subject averages in [s] durations overlapped any of the average durations of the individuals in the normal group, for either singleton [s] duration data or clustered [s] duration data. Comparison of average rank for each group revealed a difference of 4 places, a difference which remained constant across all four different comparisons. Subject rankings in the experimental group were stable on the comparison of mean [s] durations at their mid-treatment and post-treatment points on singleton [s] duration comparisons. Two of these subjects maintained their relative rankings across both the mid- and post- treatment [s] cluster duration comparisons. One of those subjects, M1, consistently held the same rank as being the experimental subject with the longest mean duration for [s] production across both mid- and post-treatment points for both singleton and clustered /s/. The only measure that indicated a difference in relative intrasubject variability between the subjects in the two groups was that of /s/ clusters at mid-treatment.

When the average [s] duration for the experimental group was compared to the average for the normal group on singleton [s] duration, the experimental group at their mid-treatment point differed from the normals by 120 msec, and increased that difference to 145 msec by the post-treatment measurement point. However, on the comparison of the mean durations of the two groups on clustered [s] duration the experimental subjects still were not within one standard deviation of the mean of the normals but the gap was considerably reduced relative to the singleton /s/ comparison at midpoint. In fact, the experimental subjects' group mean at their post-treatment point did approximate the mean of the normals for clustered [s] duration. Visual inspection of the relative variability differences between the two different groups revealed that the experimental subjects did in fact demonstrate increased variability in their mean [s] durations across both measurement points for both singleton /s/ and for clustered /s/ at post-treatment when compared to the relative variability demonstrated by the normal group.

Measures of Vowel To Vowel Duration

Individual Experimental Subject Performance

Figure 18 represents each of the experimental subject's mean vowel to vowel durations for three different intended phonetic targets at a pre-treatment point. Prior to treatment all of the phonetic targets represented in this figure, namely consonant stops, singleton /s/, and /s/ clusters were all represented by stops. One of the questions under investigation in this study was whether or not the error productions that the children produced were more similar in durational characteristics to intended stops in an intervocalic environment, or more similar to /s/ in an intervocalic environment. The vowel to vowel duration measures were used to compare the stops occurring in their normally intended contexts and in contexts in which they occurred in place of /s/. The first target was the stop consonant and its cognate that an individual



<u>Figure 18.</u> Mean vowel to vowel duration for intended stops, [s] singletons, and [s] clusters occurring in intervocalic contexts at the pre-treatment measurement point by experimental subject.

subject substituted for [s]. The designation of "stop" is added here to indicate that that particular stop consonant was the subject's intended target. Its cognate was included for mean duration measures since the subjects sometimes modified voicing characteristics of the stop which was substituting for [s].

Figure 18 represents the mean vowel to vowel durations for contexts in which the individual experimental subjects produced intended stops intervocalically, as well as contexts in which they produced their error stops when /s/ should have occurred intervocalically in both /s/ singleton and /s/ cluster environments. The means, standard deviations, and coefficients of variation for these pre-treatment measures are provided in Table 14.

Figure 18 reveals that Subject C2 exhibited the shortest range in mean durations among the three different contexts sampled. This subject exhibited almost identical mean durations for contexts containing intended stop consonants and those in which the child erroneously stopped for /s/ singleton. This subject's mean duration for vowel to vowel contexts containing /s/ clusters was only 20-21 msec longer than those containing intended stops and the stop for singleton /s/ errors. His range across all three measures was 193-214 msec, or 21 msec.

Subject C1 exhibited the greatest range of any of the experimental subjects among the three different phonemic

Table 14. Means, standard deviations (in parentheses) and coefficients of variation (%) of vowel to vowel duration in speech probe items produced by experimental subjects

	SUBJECT			
TREATMENT POINT/ PHONETIC CONTEXT	M1	C1	M2	C2
Pre- stop	179 (54) 30% n=20	199 (83) 42% n=20	159 (51) 32% n=18	194 (52) 27% n=19
Pre- /s/ singleton	228 (62) 27% n=9*	256 (147) 58% n=10	238 (54) 23% n=10	193 (37) 19% n=10
Pre- /s/ cluster	218 (37) 17% n=5	341 (144) 42% n=5	207 (22) 11% n=5	214 (68) 32% n=5
Mid- /s/ singleton	698 (270) 39% n=10	343 (51) 15% n=10	194 (37) 19% n=10	230 (61) 27% n=10
Mid- /s/ cluster	767 (355) 46% n=5	432 (113) 26% n=5	515 (131) 25% n=5	529 (36) 68% n=4*
Post- /s/ singleton	563 (133) 24% n=10	293 (35) 12% n=9*	169 (21) 12% n=9*	280 (44) 16% n=9*
Post- /s/ cluster	727 (155) 21% n=5	397 (34) 9% n=5	352 (33) 9% n=5	432 (75) 17% n=5

<u>NOTE</u>. Twenty stop consonant items were submitted for analysis for each subject at the pre-treatment measurement point. At each measurement point, ten /s/ singleton items and five /s/ cluster items were submitted per child.
* - Numbers show differences because spectrographic representation was insufficient for analysis.

contexts. In this subject's case, the mean vowel to vowel duration containing the intended stops (199 msec) was the shortest, followed by contexts which should have contained the /s/ singletons (256 msec). His longest mean vowel to vowel duration was that of contexts which should have contained /s/ clusters (341 msec). In the case of this subject, the closest two measures, those involving intended stop environments and /s/ singleton environments were 57 msec apart. His range across all three measures was 199-341 msec, or 142 msec.

Subject M1 exhibited his shortest mean vowel to vowel duration on his intended stop consonant contexts (179 msec). His mean durations for the contexts which should have contained /s/ singleton (228 msec) and /s/ cluster (218 msec) were only 10 msec apart. This subject's range across all three contexts was 179-228 msec, or 49 msec.

Subject M2 exhibited her shortest mean vowel to vowel duration on her intended stop consonant contexts (159 msec) which was the shortest single mean vowel to vowel duration of any of the experimental subjects in the pretreatment measures. Subject M2 exhibited her longest mean duration on the /s/ singleton contexts (238 msec) and a mean of 207 msec on her /s/ cluster contexts. Her range across all three contexts was 92 msec.

At the pretreatment measuring point both of the cognitive approach subjects exhibited shorter mean vowel to vowel durations in the /s/ singleton environments than in the /s/ cluster environments. Both of the motor approach subjects at this point exhibited shorter mean vowel to vowel durations for the /s/ cluster environments than for the /s/ singleton environments.

Visual inspection of Figure 18 suggests that for three of the experimental subjects, M1, C2, M2, the stops produced for intended stops exhibited the lowest mean vowel to vowel durations of the three phonetic targets. Subject C2, however, exhibited mean intended stop vowel to vowel durations which were similar to his intended singleton /s/ vowel to vowel duration.

Individual Subject Description Relative to The Experimental Group

Figure 19 displays the mid-treatment mean vowel to vowel durations involving /s/ singletons and /s/ clusters for each of the experimental subjects. (The means, standard deviations, and coefficients of variation for the vowel to vowel duration data on the experimental subjects may be found in Table 14). Visual inspection of this figure reveals that Subject M1 exhibited extremely long mean durations for both the /s/ singleton and /s/ cluster measurements. Subject M2 revealed the greatest within

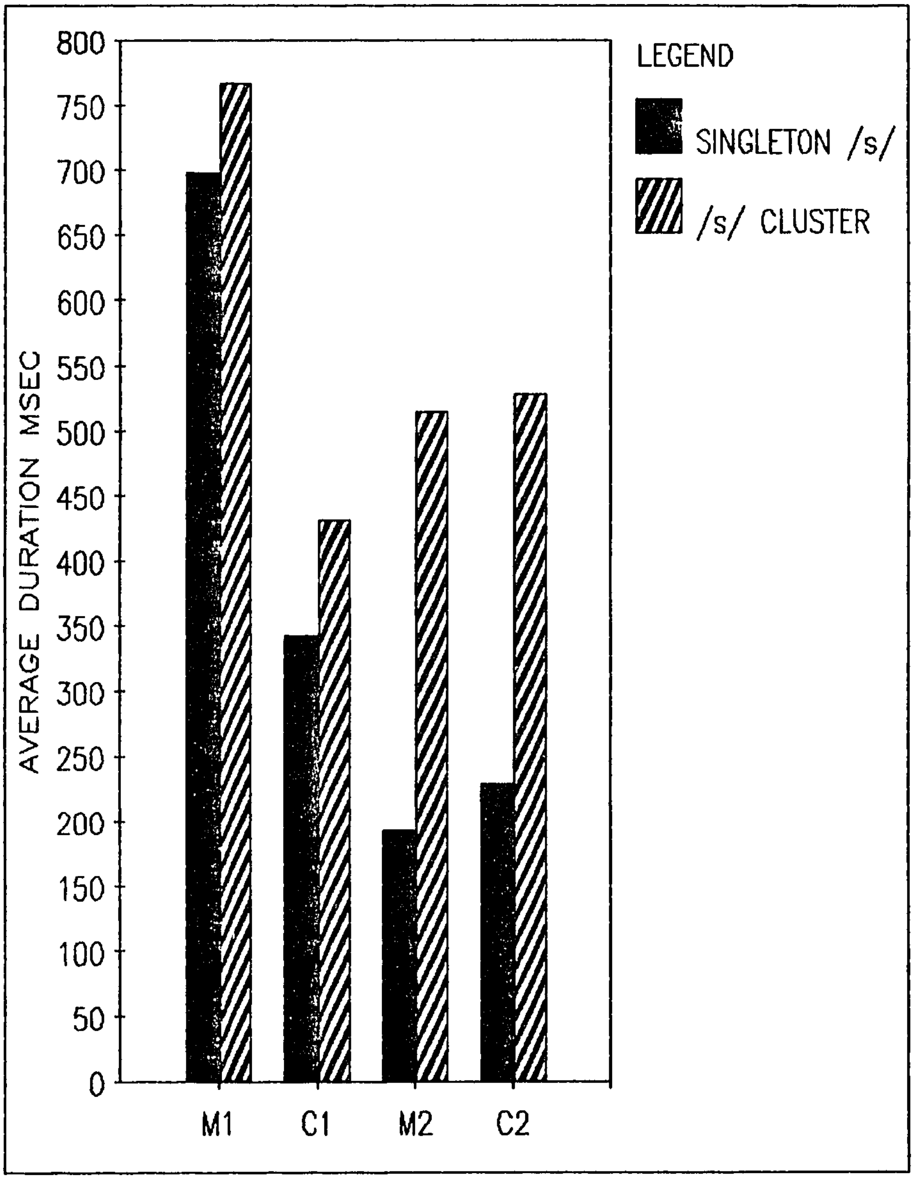


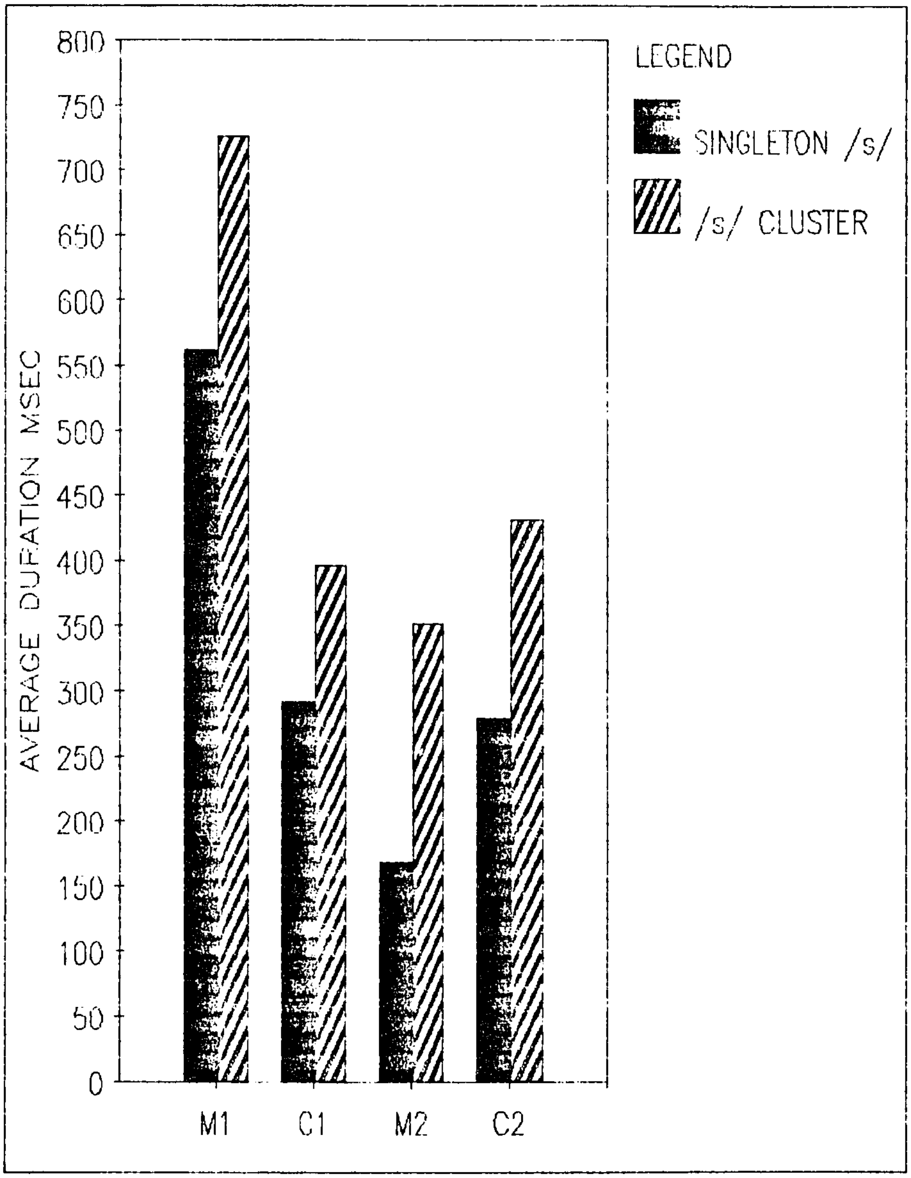
Figure 19. Mid-treatment mean vowel to vowel durations of /s/ singleton and /s/ clusters occurring in intervocalic contexts by experimental subject.

subject difference in duration between the two contexts, followed by Subjects C2, C1 and then Subject M1. Subject M2 exhibited the closest approximation of any of the normal subjects' mean vowel to vowel durations for /s/ singleton with a mean duration of 194 msec compared to Subject N3 who exhibited a mean duration of 179 msec, a 15 msec difference. The normal subject's individual mean vowel to vowel durations, standard deviations, and coefficients of varialon may be found in Table 15.

Table 15. Means, standard deviation (in parentheses) and coefficients of variation (%) on vowel to vowel duration, /s/ singleton and /s/ cluster items produced by normal subjects

	SUBJECT			
TREATMENT/ CONTEXT	N1	N2	N3	N4
/s/ singleton	145 (23) 16% n=10	143 (26) 18% n=10	179 (22) 12% n=10	124 (18) 14% n=10
/s/ cluster	221 (36) 16% n=5	244 (35) 14% n=5	256 (30) 11% n=5	197 (14) 7% n=5

Figure 20 displays the post-treatment mean vowel to vowel durations involving the /s/ singletons and /s/ clusters for each experimental subject. Subjects M1, C1,



<u>Figure 20.</u> Post-treatment mean vowel to vowel durations of /s/ singleton and /s/ clusters occurring in intervocalic contexts by experimental subject.

and M2 exhibited decreased mean durations relative to singletons and clusters from the mid-treatment measurement to post-treatment. Subject C2 however, exhibited a longer mean vowel to vowel duration for /s/ singleton though he did reduce his mean duration for /s/ clusters at post-treatment. However, all four subjects exhibited reductions in variability and relative intrasubject variability around their respective means from mid-treatment to post-treatment. All four subjects exhibited substantially greater reductions in relative variability and variability in clusters compared to singletons.

Rank Order of Individual Subjects Relative to Their Respective Average Vowel to Vowel Durations

Rank ordering of the experimental subjects on pre-treatment vowel to vowel measures. The same ranking procedures used in [s] duration comparisons was applied to the mean vowel to vowel durations. These duration measures are important because they include the pre-treatment duration measure of the experimental subjects' stop for [s] errors as well as the mean durations of their intended stop consonants.

At the pre-treatment measuring point, the experimental subjects were ranked from highest (longest mean duration) to lowest (shortest mean duration) for the vowel to vowel durations in which normally intended stop consonants occurred intervocalically: C1 (199 msec); C2 (194 msec); M1 (179 msec); and M2 (159 msec). These subjects were then ranked in the same way for mean duration of vowel to vowel measures in which they produced stops for the [s] singletons which occurred intervocalically: C1 (256 msec); M2 (238 msec); M1 (228 msec); and C2 (193 msec). Next, all eight means were ranked highest to lowest across the two sets of means resulting in the following: 8-C1 (256 msec); 7-M2 (238 msec); 6-M1 (228 msec); 5-C1 (199 msec); 4-C2 (194 msec); 3-C2 (193 msec); 2-M1 (179 msec); 1-M2 (159 msec). One subject, C2, exhibited almost identical mean durations for his stop for [s] vowel to vowel durations and his intended stops vowel to vowel duration. In addition to this subject's mean overlapping the two sets, Subject C1's mean also overlapped the two sets.

The experimental subjects were then ranked relative to their respective mean vowel to vowel durations in which /s/ clusters occurred intervocalically. Their rankings were as follows: C1 (341 msec); M1 (218 msec); C2 (214 msec); and M2 (207 msec). These subject rankings were compared to those of the same subjects for the mean vowel to vowel durations involving the intended stop consonants. Although there was no overlapping, three subjects' durations in this last set of measures did approximate within 20 msec Subject C1's mean duration for the intended stop consonants.

Subjects M1 and C2 exhibited the least within subject difference across mean vowel to vowel durations for the different phonetic contexts.

A comparison was made between the experimental subject's pre-treatment intended /s/ singleton and intended /s/ cluster mean vowel to vowel durations. There was considerable overlap in this comparison across the subjects on the two measures: C1- 341 msec (cluster); C1- 256 msec (singleton); M2- 238 msec (singleton); M1- 228 msec (singleton); M1- 218 msec (cluster); C2- 214 msec (cluster); M2- 207 msec (cluster); and C2- 193 msec (singleton). Their across measure rankings were for intended singleton /s/: 7, 6, 5 and 1. Their rankings on the intended clusters were: 8, 4, 3 and 2. Their average rankings then were 4.75 for the intended singleton /s/ measure, and 4.25 for intended clusters. Intrasubject variability for intended /s/ clusters relative to singletons revealed decreases in two subject's performances; one remained essentially the same, and one subject exhibited an increase.

Comparisons of mean durations and relative intrasubject variability across the three phonemic contexts (Table 14) revealed that each experimental subject varied considerably between any two contexts in terms of both mean duration and relative variability except for two instances. Subject M1 exhibited similiar relative variability but differences in mean duration on the intended stops vs /s/ singleton contexts; and subject C2 demonstrated the same mean duration between intended stops and singleton /s/ contexts, but differed in relative variability.

Rank ordering comparisons across subject groups. The first comparison across groups will be that between the normal subject's mean vowel to vowel durations for [s] singletons and the experimental subject's mean vowel to vowel durations for intended stops. Figure 21 illustrates the relative duration differences between the mean vowel to vowel durations for [s] singleton environments and [s] cluster environments in the normal subjects. Figure 22 illustrates the experimental subject's relative duration differences among their respective pretreatment mean vowel to vowel durations for intended stops, [s] singletons, and [s] clusters. The experimental subjects were ranked as follows from highest (longest duration) to lowest (shortest duration) in intended stop durations: C1 (199 msec); C2 (194 msec); M1 (179 msec); and M2 (159 msec). The normal subjects were ranked for their vowel to vowel durations involving intervocalic /s/ singletons: N3 (179 msec); N1 (145 msec); N2 (143 msec); and N4 (124 msec). As can be seen, Subject N3's mean overlaps both M2's mean and M1's mean, such that when all eight subjects were ranked across

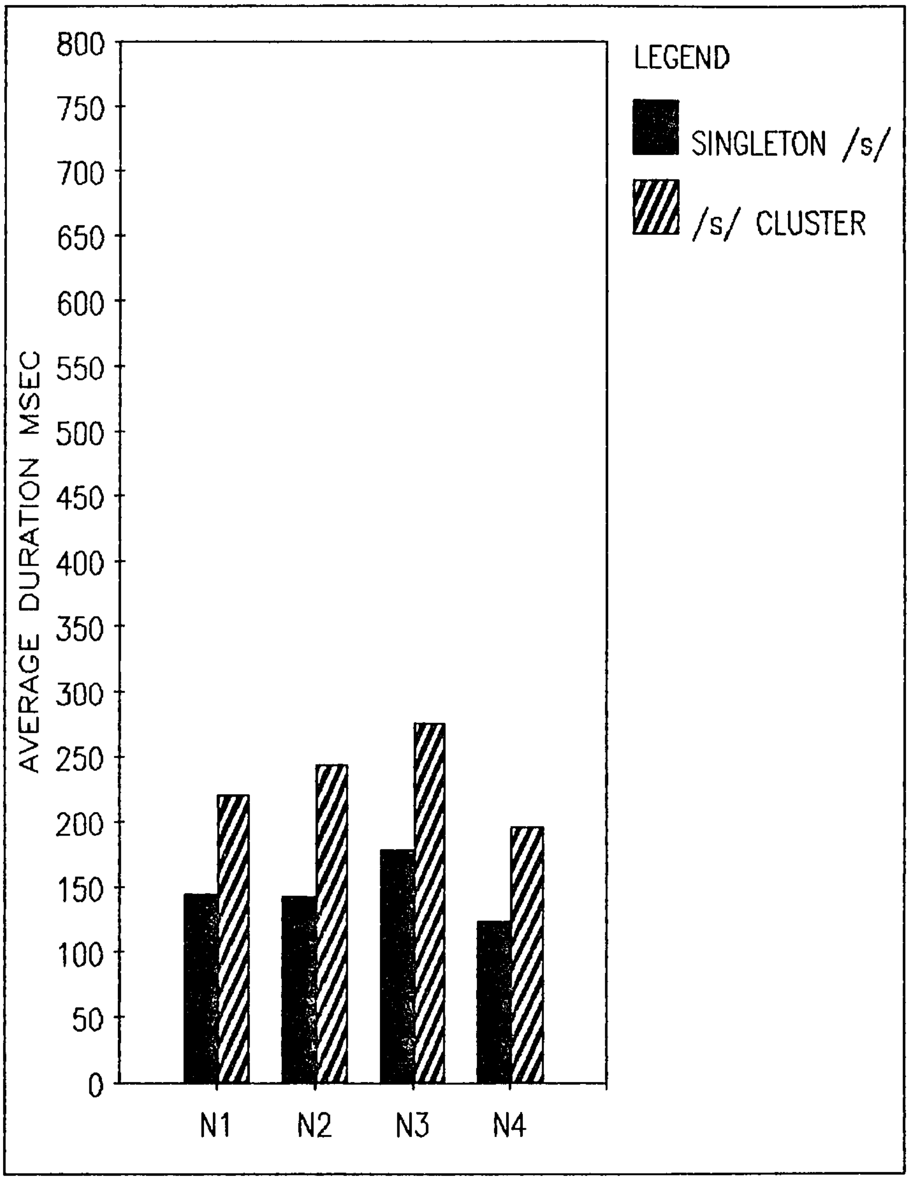


Figure 21. Mean vowel to vowel durations for /s/ singleton and /s/ cluster in normal subjects.

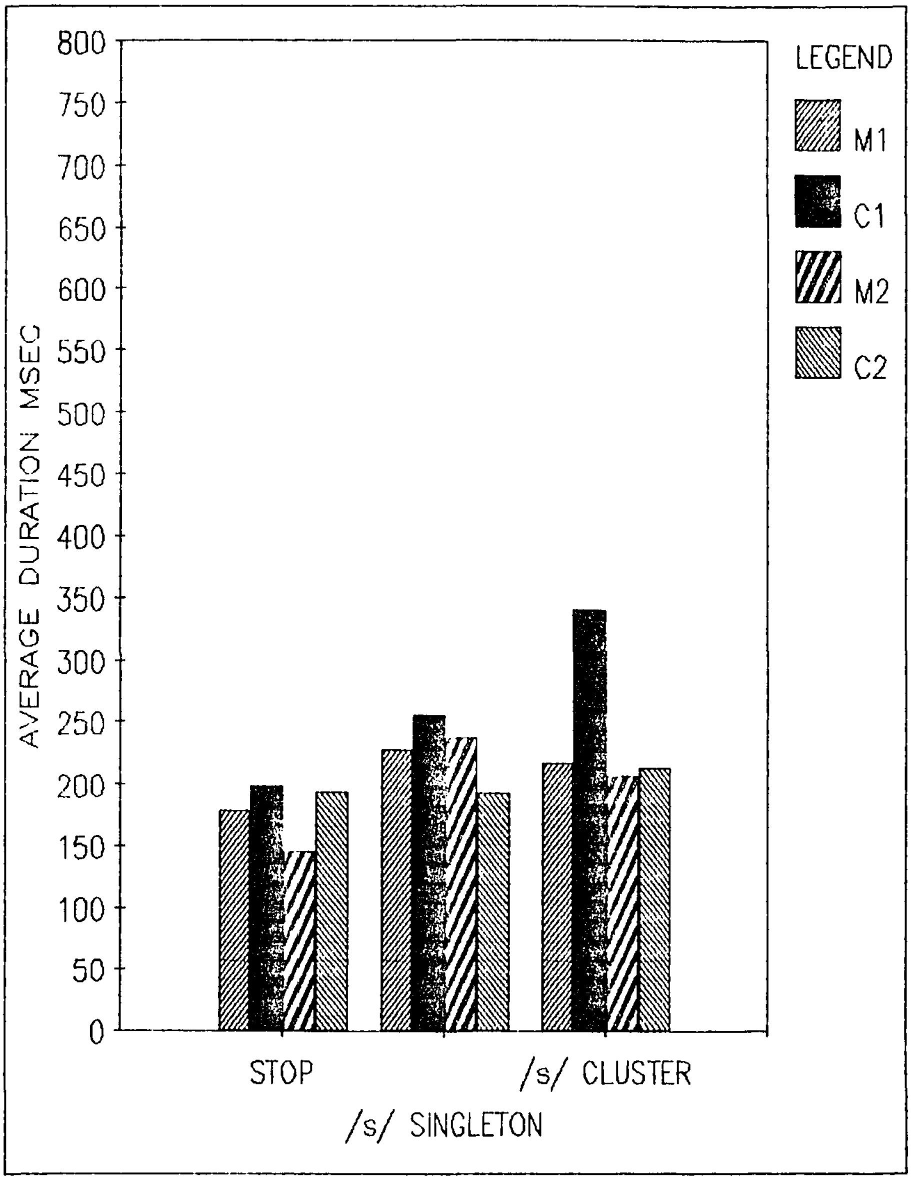


Figure 22. Relative mean durations for intended stops, /s/ singletons and /s/ clusters at pre-treatment for experimental subjects.

groups, Subjects M1 and N3 tied for 5th rank for the phonetically (and phonemically) different contexts. Each group's individual ranks were added up and divided by the number of subjects within that group to get a within group mean ranking. The experimental subjects' mean rank was 5.5 and the normal subjects' mean rank was 2.75. The normal subject's mean vowel to vowel durations in which /s/ clusters occurred were ranked as follows from highest to lowest: N3 (256 msec); N2 (244 msec); N1 (221 msec); N4 (197 msec). The experimental subjects previous within group ranking was applied again. The experimental subject's intended stop means contained the means having the shortest durations. However, Subject C1's mean of 199 msec overlapped the lower end of the normal subjects' means such that across group ranking would place Subject C1 in 5th place and N4 in 4th place with a mean [s] cluster duration of 197 msec. A within group ranking procedure was performed and resulted in an average within group rank of 6.25 for the normal group and 2.75 for the experimental group.

The next comparison is that between the experimental subject's mean vowel to vowel durations for intervocalic /s/ singleton environments at pre-treatment and the normal subjects mean durations for /s/ singleton environments. The experimental subjects ranked from longest duration to shortest were: C1, 256 msec; M2, 238 msec; M1, 228 msec;

and C2, 193 msec. Subject C2 and Subject N3, the highest ranking of the normals on means /s/ singleton vowel to vowel duration were within 14 msec of each other on this measure. The ranking then across the eight subjects would be non-overlapping, with the top four ranks, 5,6,7, and 8 belonging to the experimental group and the lower four to the normal group. The experimental subjects' average rank would then be 6.5 and the average rank for the normals would be 2.5, a difference of four places.

The pre-treatment mean vowel to vowel durations for [s] cluster environments of the experimental subjects were then compared via the within group ranking procedure with the normal subjects' [s] cluster vowel to vowel duration means. The experimental subjects ranked from longest to shortest duration were: C1, 341; M1, 218; C2 214; and M2, 207 msec. The normal subjects ranked in the same within group manner were: N3 (256 msec); N2 (244 msec); N1 (221 msec); and N2 (197 msec). There was overlap between the two groups in that Subjects N3, N2, and N1 overlapped Subjects M1, C2, and M2 on this comparison. Across group ranking of all eight subjects then would be from the subject with the longest mean duration to the one with the shortest: C1 (8), N3 (7), N2 (6), N1 (5), M1 (4), C2 (3), M2 (2), and N4 (1). Average ranking across the two groups then would be 4.75 for the Normal Group and 4.25 for the Experimental Group. Both of these ranking procedures indicate that these two groups performed in a similar manner with respect to mean duration on this measure. With regard to variability, Subjects C1 and C2 exhibited greater relative intrasubject variability about their respective means than did any of the other six subjects.

The next comparisons involve the experimental subject's respective mean vowel to vowel durations for [s] singletons and clusters at their mid-treatment and post-treatment measurement points and the normal subjects' respective means. The normal subject rankings for [s] singleton and [s] cluster mean vowel to vowel durations will remain the same since they were measured only one time. The experimental subjects at the mid-treatment measurement point were ranked from highest to lowest for their respective mean vowel to vowel durations in which /s/ singleton occurred as follows: M1 (698 msec); C1 (343 msec); C2 (230 msec); and M2 (194 msec). There was no overlap between the normal subject's mean durations and those of the experimental subjects in this comparison and therefore across group ranking would also be consistent with this difference. As can be seen in Table 14, the experimental subjects demonstrated considerable within group variability relative to individual standard deviations. Subject C1's performance fell within the normal subject's coefficient of variability range (12-18%) and Subject M2 approximated their range.

Next, these subjects were ranked from highest to lowest for their mean vowel to vowel durations for [s] singleton at their post treatment measurement point: M1 (563 msec); C1 (293 msec); C2 (280 msec); M2 (169 msec). Subject N3's mean (179 msec) did overlap that of Subject M2. Across group ranking then would result in: M1 (8) C1 (7); C2 (6); N3 (5), M2 (4) N1 (3); N2 (2); and N4 (1). The average rank of each group then would be: 6.25 for the experimental subjects and 2.75 for the normal subjects. At this measurement point also, all four of the experimental subjects had reduced their within subject variability, and three subjects, C1, M2, and C2 exhibited relative intrasubject variability that was within the normal subjects' range (Table 14).

The /s/ cluster comparison between the normal subjects and the experimental subjects at the mid-treatment measuring point came next. The experimental subjects were ranked as follows: M1 (767 msec); M2 (515 msec); C1 (432 msec); C2 (529 msec). The two groups were highly dissimilar on this comparison. A difference between groups was revealed on this measure with regard to relative intrasubject variability (Tables 14 and 15).

The experimental subjects were then ranked from highest to lowest relative to their respective vowel to vowel mean durations involving [s] clusters at the post-treatment measurement point: M1 (727 msec); C2 (432 msec); C1 (397 msec); M2 (352 msec). There was no overlap between groups in this comparison. The lowest experimental subject mean duration of 352 msec (M2) was 96 msec greater than the highest of the normal mean durations, that of Subject N3, 256 msec. However, all four of the experimental subjects demonstrated reduced within subject variability on this measure, and two subjects, C1 and M2 demonstrated comparable relative intrasubject variability with the normal subjects. Average ranking across the two groups reflected a four place difference on both of these last comparisons.

Mean Vowel to Vowel Duration Comparisons Between Normal and Experimental Subject Groups

Pretreatment. Comparisons of the within and across group means and standard deviations were made for the mean vowel to vowel measures. A comparison of the experimental subjects' pre-treatment mean duration of intended stops and their mean duration for error stops (which occurred in the place of singleton /s/) was calculated first. The experimental subjects' mean duration for the intended stops was 180 msec (standard deviation of 24 msec) and their mean for the error stops which occurred in place of singleton /s/ was 229 msec (standard deviation of 27 msec). The subjects' mean for the error stops did not approximate the mean for their intended stops since the two means differed by 49 msec. Comparison of relative group variability using coefficients of variation indicated similiar variability between intended stops (coefficient of variability of 13%) and /s/ singletons (coefficient of variability of 12%).

Next, the experimental subjects' mean vowel to vowel duration for the pre-treatment measure on /s/ clusters (which at that time were reduced to stops) was also compared to their mean for intended stops. Their /s/ cluster mean vowel to vowel duration was 245 msec with a standard deviation of 64 msec. Since this mean was greater than that of the /s/ singleton mean, it did not fall within one standard deviation of the mean for the experimental subjects' intended stops. Comparison of relative group variability also indicated a difference between intended stops (coefficient of variability of 13%) and intended /s/ clusters (coefficient of variability of 26%).

The experimental subjects as a group demonstrated a trend of increased mean duration as is visibly evident in looking across their mean vowel to vowel durations for the intended stops (180 msec), to their mean for /s/ singleton environments (229 msec), to their mean for /s/ cluster environments (245 msec). Though their relative group variability was similar between the first two means, they exhibited an increase in variability as well as mean duration on their mean vowel to vowel duration for /s/ cluster environments.

The normal subjects' mean vowel to vowel duration for /s/ singleton environments was 148 msec with a standard deviation of 23 msec. Their mean duration for /s/ cluster environments was 230 msec with a standard deviation of 26 msec. The experimental subjects' pre-treatment mean vowel to vowel duration for the /s/ singleton environment, even though the subjects used stops at that time in place of /s/, was longer than that of the normals who produced /s/ by 81 msec, though the relative variability was comparable between groups (Normal subjects' coefficient of variation for /s/ singletons was 15%; for experimental subjects' it was 12% on the same measure). The experimental subjects' pre-treatment vowel to vowel duration for /s/ cluster environments however, was within one standard deviation of the normals' mean for /s/ clusters, though the relative variability of the experimental group was more than twice as great (Normal subjects' coefficient of variation for /s/ clusters was 11% and was 26% for experimental subjects on the same measure).

Midtreatment. The experimental subjects' mean vowel to vowel duration for /s/ singleton environments at mid-treatment was increased by 138 msec relative to the same measure at pre-treatment, and variability was greatly increased. The experimental subjects' mean vowel to vowel duration for /s/ singleton environments at the mid-treatment measure was compared to the normals /s/ singleton vowel to vowel duration mean. The experimental subjects' mean of 366 mec (standard deviation of 230 msec) was over twice as long as that of the normal subjects'. The experimental subjects' relative variability increased to 63% as a group at mid-treatment.

The experimental subjects' mean duration for /s/ cluster environments at midtreatment measurement was 561 msec with a standard deviation of 144 msec, and coefficient of variation was 27%. This mean was twice as great as their pre-treatment mean for this measure though their relative group variability was similiar to that at pre-treatment. The experimental subjects' /s/ cluster mean at mid-treatment was more than twice as long as the normal subjects' mean for /s/ cluster environments, and their relative group variability was greater also.

Post-treatment. The experimental subjects's post-treatment mean vowel to vowel duration for /s/ singleton environments was 326 msec (standard deviation of 167 msec, and coefficient of variation was 51%) and for /s/ cluster environments the mean vowel to vowel duration was 477 msec (with a standard deviation of 170 msec, and coefficient of variability of 36%). The trend for the experimental subjects as a group at post-treatment was that they exhibited reductions in both means relative to mid-treatment. They reduced relative variability for /s/ singletons but increased it for /s/ clusters from mid- to post-treatment. There was a decrease in both of the experimental subjects' means of about 40 msec from mid-treatment to post-treatment measurement, though neither of the experimental subjects' post-treatment group means approximated those of the normal subjects'. Their relative group variability also was considerably greater at post-treatment compared to the normal subjects.

Comparison of Performance between the Subjects in the Sensory Motor Approach and the Cognitive Approach

Figure 23 illustrates the relative duration changes over time exhibited by each of the experimental subjects on mean vowel to vowel duration on /s/ singletons and Figure 24 illustrates the changes over time on /s/ clusters. In Figure 23, Subjects M1 and M2 appear at opposite extremes at the mid- and post-treatment measurement points on /s/ singleton environments, while the relationship changes for /s/ cluster environments as can be seen in Figure 24. Subject M1's overall pattern from pre- to post treatment for the /s/ cluster environments is similar to that in /s/ singleton environments. Subject M2 on the other hand exhibited a different trend on the /s/ cluster environments

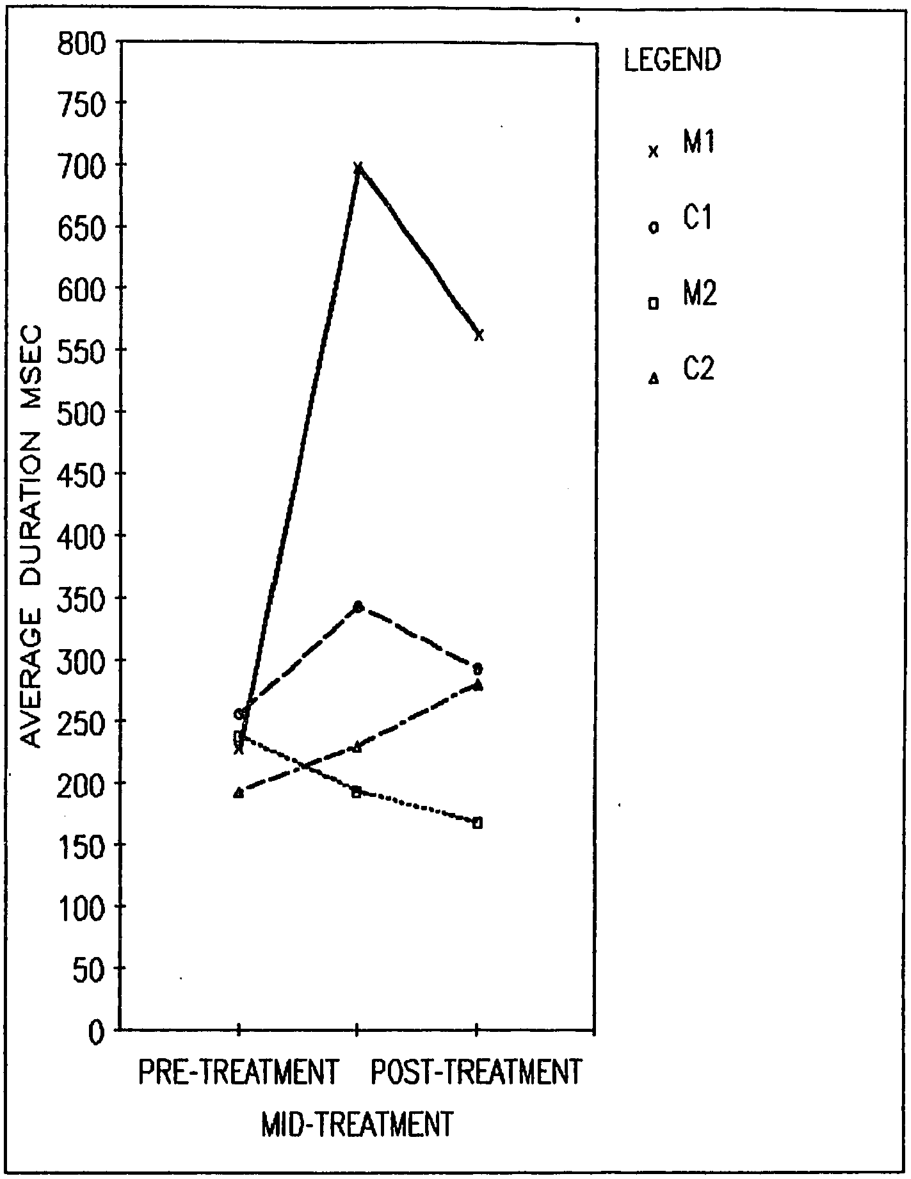


Figure 23. Relative duration changes over time exhibited by each of the experimental subjects on mean vowel to vowel durations of intervocalic /s/ singletons.

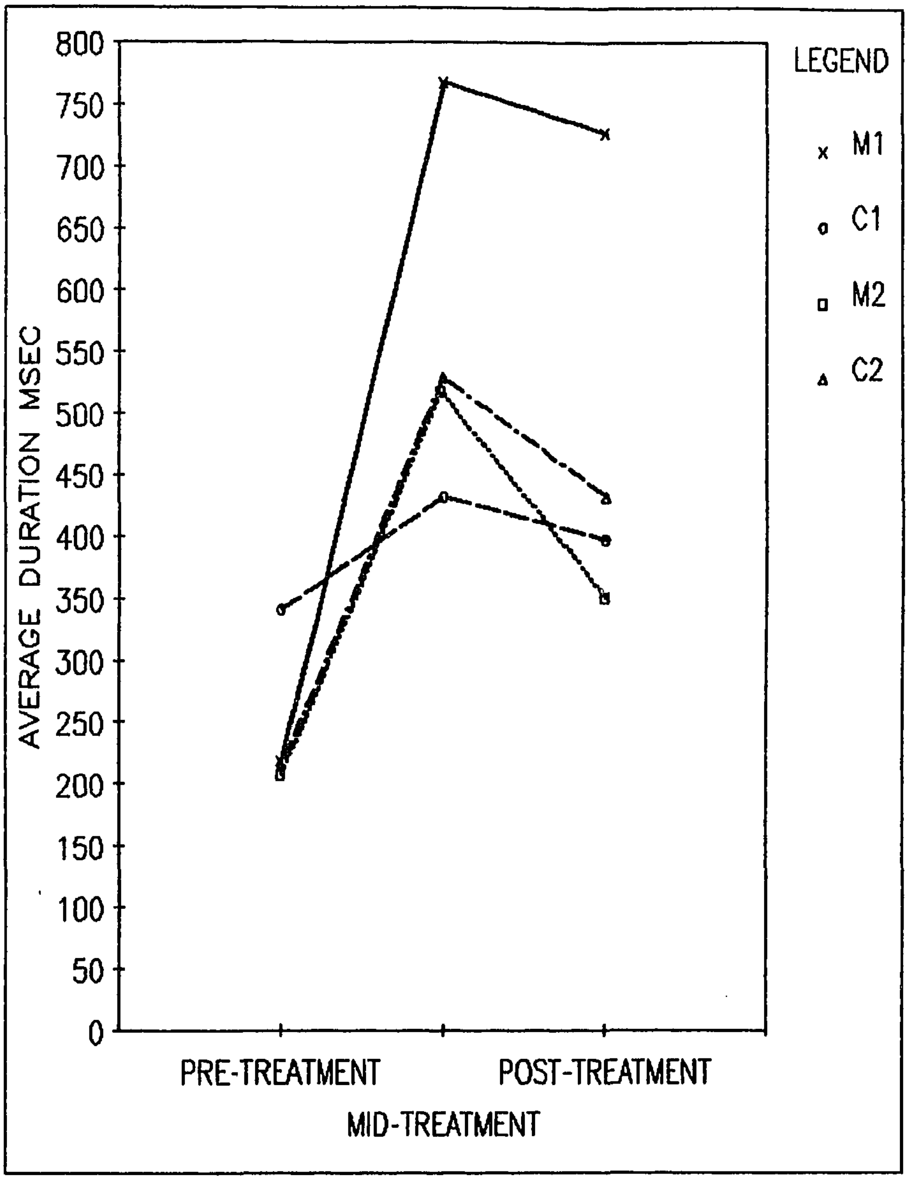


Figure 24. Relative duration changes over time exhibited by each of the experimental subjects on mean vowel to vowel durations of intervocalic /s/ clusters.

from that on the /s/ singletons.

As in the measures involving [s] duration, Subject M1 maintained his status within the experimental subject group as the subject having the longest mean vowel to vowel durations for both /s/ singletons and /s/ clusters. Subject M1 exhibited a dramatic increase in mean vowel to vowel duration for /s/ singleton environments at mid-treatment relative to his pre-treatment mean at which time he produced stops for [s]. He decreased his mean in /s/ singleton environments as well as variability at the post-treatment measurement point, though his mean still did not approximate any of the other experimental subject's means at that point.

Subject M1's means for /s/ cluster environments at both mid- and post-treatment measurement points more closely approximated those of the other experimental subjects, due to their respective relative increases. Subject M1 decreased his mean vowel to vowel duration and his relative intrasubject variability for /s/ cluster environments at post-treatment measurement, though he still exhibited greater relative variability of any of the individual normal subjects.

Subject M2's progression from pre-treatment performance through post-treatment performance revealed a steady decrease in both mean vowel to vowel duration of /s/ singleton environments (Figure 23), as well as in variability. In contrast to Subject M1, this subject's mid-treatment and post-treatment means were the shortest of any of the experimental subject's at those points in time for /s/ singleton environments. Subject M2 exhibited the closest approximation of any of the normal subjects' mean vowel to vowel durations for /s/ singletons with a mean duration of 194 msec compared to that of Subject N3 who exhibited a mean duration of 179 msec (Table 15). For /s/ cluster environments (Figure 24), Subject M2 exhibited an increase in mean duration relative to his pre-treatment mean, as did Subject M1. Subject M2's mean vowel to vowel duration for /s/ cluster environments at post-treatment was decreased relative to her mid-treatment mean, as was the case with Subject M1. Additionally, Subject M2's relative variability in the cluster environments was substantially reduced from 25% to 9%, at which point her variability approximated that of the normal subjects. As can be seen in Figure 23, Subject M2's overall trend from pre-treatment to post-treatment for /s/ clusters was different from that in her /s/ singleton performance.

Even though M1 and M2 exhibited the greatest difference in terms of the absolute mean vowel to vowel durations for the /s/ singleton environment among the experimental subjects, they both exhibited decreased mean durations from their respective mid- to post-treatment points, which was consistent with sensory motor assumptions. On /s/ cluster vowel to vowel mean durations, Subjects M1 and M2 demonstrated similar trends over time, and exhibited decreased mean durations at post-treatment relative to mid-treatment, once again performing in accordance with the assumptions of the sensory motor approach.

The two subjects in the cognitive approach did not exhibit the contrast in terms of absolute differences in their means that the sensory motor approach subjects did, however, the cognitive approach subjects did exhibit opposite trends from mid- to post-treatment measurement points. As can be seen in Figure 23, Subject C1 exhibited an increase in mean duration on /s/ singleton environment from pre-treatment to mid-treatment, followed by a decrease in mean duration at the post-treatment measurement point. Subject C1 demonstrated an increase in mean duration from pre-treatment to mid-treatment for /s/ cluster environments followed by a decrease in mean duration at the post-treatment point. He decreased mean durations and relative intrasubject variability from the mid-treatment points to post-treatment points for both /s/ singleton environments and cluster environments. Subject C1 exhibited steady decreases in relative instrasubject variability from pre- to post-treatment for both the vowel to vowel /s/ singleton mean durations and for /s/ clusters as well. Relative intrasuject variability for this subject at post-treatment for both singleton and cluster environments was within the normal subjects' relative instrasubject variability range.

Subject C2 exhibited almost identical mean vowel to vowel durations at pre-treatment for both the intended stops as well as /s/ singletons. This subject was the only one who demonstrated a steady increase in mean duration for /s/ singleton environments from pre-treatment to post-treatment measures (Figures 23 and 24). His relative intrasubject variability increased at mid-treatment relative to pre-treatment in both singleton and cluster environments, but decreased from mid-treatment to post treatment. Subject C2's post-treatment mean for the /s/ cluster environments exceeded that of Subject C1.

Comparison of Performance Across Experimental Subjects Results

In regard to the /s/ singleton environments, Subjects M1, C1, and M2 demonstrated reductions in mean durations from mid-treatment measurement to post-treatment measurement. Subject C2 demonstrated an increase in mean duration over that time. However, three subjects demonstrated an increase in mean duration from pre-treatment to mid-treatment, Subjects M1, C1, and C2. Subject M2 demonstrated a decrease from pre-treatment to the mid-treatment measure on /s/ singleton envirionments.

In the case of the cluster environments for mean vowel to vowel durations, all four subjects exhibited similar individual trends from the mid-treatment to post-treatment points. All four experimental subjects demonstrated increases in mean duration from pre-treatment to mid-treatment on the mean vowel to vowel durations for /s/ cluster environments.

The experimental subject's respective mean vowel to vowel durations for clusters consistently exceeded those for /s/ singletons at both mid-treatment and post-treatment points. Relative intrasubject variability was consistently smaller across subjects at the mid-treatment point on /s/ singletons than on clusters. However, at post-treatment relative intrasubject variability was similiar across singleton /s/ and clustered /s/ environments. Also, at post-treatment, three experimental subjects fell within the normal relative variability range and, two experimental subjects were within the normal relative variability range for /s/ cluster. Subject C1 exhibited essentially equivalent variability about the mean for both singleton and cluster environments at the post-treatment measurement point.

A number of trends have been suggested by the material just presented in the section on vowel to vowel duration measures relative to individual and group performance. First, the normal subject's /s/ singleton mean durations did not overlap between their respective /s/ singleton and

/s/ cluster mean durations (Table 15). Their /s/ singleton means, ranging from 124 msec to 179 msec, were shorter than their respective intrasubject /s/ cluster mean durations. Also, all four of their /s/ singleton means were shorter than their four /s/ cluster means. Relative intrasubject variability was similar for their respective /s/ singleton and /s/ cluster environments.

At the pre-treatment point the experimental subject's shortest mean durations were their respective intended stops, except for Subject C2, who did not exhibit a duration difference between his intended stop mean and that of his /s/ singletons. The experimental subject's intended stop means did not overlap their /s/ singleton means except in the case of Subject C2. Further, three of the experimental subject's /s/ cluster means were shorter than three of their /s/ singleton means, which as a group, was the reverse of the case for the normal subjects. On an intrasubject basis, two of the experimental subjects exhibited longer cluster means than singletons. However, all four experimental subjects exhibited a difference in relative intrasubject variability between their respective /s/ singleton and /s/ cluster phonetic environments.

A comparison between the normal subject's means for [s] singleton vowel to vowel durations and the intended stop mean durations for the experimental subjects revealed overlapping means. The normal subject's [s] cluster mean durations were compared to the experimental subject's means for the intended stops and these two sets of means also overlapped.

The experimental subject's pre-treatment vowel to vowel mean durations for [s] singleton environments were compared with the normal subject's mean durations for the [s] singleton environments and no overlapping occurred between the two sets, with the experimental subjects exhibiting longer mean durations. The experimental subject's also exceeded the normal subject's relative intrasubject variability range for /s/ singletons on this measure. There was overlapping between the experimental subject's pre-treatment [s] cluster vowel to vowel means (which were reduced to stops) and the normal subject's [s] cluster vowel to vowel means. The experimental subject's also exceeded the normal subject's relative intrasubject variability range for /s/ clusters.

The mid-treatment [s] singleton mean durations and the [s] cluster durations of the experimental subjects were then compared to the same measures respectively, for the normal subjects. There was no overlap between the experimental subject's means for either the mean vowel to vowel durations for the [s] singleton or [s] cluster environments, and those of the normal subjects. The experimental subjects exhibited longer mean durations than the normals at the mid-treatment point, for both /s/

singletons and /s/ clusters. Three of the four experimental subjects exceeded the normal subject's relative intrasubject variability range for /s/ singletons, while all four of the experimental subjects exceeded the normal subject's relative intrasubject variability range for /s/ clusters.

On post-treatment comparisons, three of the four experimental subjects exhibited greater mean durations than any of the normal subjects on the /s/ singleton measure. For /s/ clusters, the four experimental subjects all exhibited greater mean durations than the normal subjects, such that there were no overlapping mean durations on this measure. The experimental subjects exhibited similar relative intrasubject variability to the normal subjects on both the /s/ singleton and /s/ cluster measures at post-treatment. With regard to treatment differences between the two groups of experimental subjects, the results were mixed relative to both mean durations and relative intrasubject variability, at both mid- and post-treatment.

COMPARISON OF PERCEPTUAL CATEGORIZATION ABILITY IN THE NORMAL AND EXPERIMENTAL SUBJECTS

The third major question addressed in this study was whether or not pre-school /s/ misarticulators who lack the continuancy aspect of /s/ demonstrate difficulty in tasks involving perceptual categorization of /s/ when compared to the normal peer group. Beyond that, it was also of interest in this study to determine whether treatment type differentially affected improvement on perceptual categorization of error sounds. Specifically, did children in the cognitive approach demonstrate improvement in their perceptual categorization of error sounds following treatment?

There were two primary measures used to address the question of perceptual categorization , the auditory identification measure and the 4IAX Auditory Discrimination Measure. Each measure will be discussed separately.

Results of Performance on the Auditory Identification Measure

This task was presented in two parts, which, for discussion purposes, will be referred to as Task 1 and Task 2. Task 1 involved the contrasts of /s,t/ and /k/ in word final position in minimal pairs, and Task 2 involved the same contrast but in word initial position. The performance of the normal subjects on the auditory identification measure for both tasks may be found in Table 16. There were thirty responses per task, each worth one point so that a perfect score would be 30. None of the normal subjects demonstrated a perfect score. Their scores on the first task ranged from 22 to 29 correct responses.

None of their errors involved an /s/ contrast. All involved /t/ vs. /k/ contrasts. On Task 2, normal subjects' scores ranged from 20 to 28 correct responses. Once again all errors were confined to /t/ vs. /k/ contrasts and no /s/ contrast errors were involved. Interestingly, subject N4 exhibited the highest score for Task 1 and the lowest score for Task 2. Examination of the within subject performance across the two separate tasks indicated a two point difference for N1 and N3; a 6 point difference for N2 and 9 points for N4.

The scores for the experimental subjects on the auditory identification measures are found in Table 17. None of the experimental subjects exhibited perfect scores on the pre-treatment measures. Their scores ranged from 24-28 on the pre- treatment measure on Task 1, and from 28-30 on the post treatment measure of the same task. On the first task at the pre-treatment point a normal subject, N4, had the highest score, 29. Continuing from high to low scores in descending order across subjects in both groups were: Subject C1, M2, N3 and M1. These were followed by Subjects N1 and C2 each of whom had scores of 24, and they were followed by Subject N2 who had the lowest score of 22. As can be seen, there was considerable overlapping of subjects from both groups in terms of perceptual categorization performance on this task.

Table 16. Auditory Identification: Normal Subject's Performance Results Expressed in Number of Correct Responses out of a Total of Thirty Items

SUBJECT

	N1	N2	N3	N4
Task 1	24	22	26	29
Task 2	26	28	24	20

Table 17. Auditory Identification: Experimental Subject's Performance Results for Pre- and Post- Testing Expressed in Number Correct out of a Total of Thirty Items

SUBJECT

	C1		M1		C2		M2	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Task 1	28	30	25*	29	24	28	27	29
Task 2	22	28	20	24	23*	30	29	30

* one error in which /s/ was involved in the pair

All of the experimental subjects demonstrated improved scores from pre- to post measures. Two subjects C1 and M2 each improved by 2 points and M1 and C2 improved 4 points each. One subject, C1 attained a perfect score of 30 on post-test. At post-test, the order across both subject groups from highest score to lowest score were: Subject C1 with a perfect score of 30; followed by M1, M2 and N4, all of whom had scores of 29; followed by C2 with a score of 28; then N3, N1, and N2. Following treatment then, the experimental subjects had shifted relative positions so that they as a group demonstrated better performance than three of the four normal subjects.

On Task 2 scores on the pre-treatment measure ranged from 20 to 29. Comparing experimental subjects with normal subjects on their individual performances, the subjects in order from highest scores to lowest were: M2, with a score of 29; N2, N1, N3, C2, C1, and N4 and M1 each with a score of 20. At post-treatment the experimental subject's scores ranged from 24 to 30 on Task 2. Two subjects, Subject C2 and M2 each attained perfect scores on post-test on this task. The post-treatment order of subjects from highest scoring subject to lowest was: Subjects C2 and M2 with perfect scores of 30 each; Subjects C1 and N2 with scores of 28; N1; Subjects N3 and M1 each with a score of 24; and Subject N4 with a score of 20. Once again as in Task 1, following treatment the experimental subjects as a group shifted their relative individual positions demonstrating performance which was better than and as good as that of the normal subjects in categorical perception.

The Mann Whitney U test was applied to the scores achieved by the two groups on each of the auditory identification measures for both pre- and post-tests ($n1 = 4$; $n2 = 4$; alpha = .05, one-tailed test). Ties were assigned the average of the ranks they would have had if no ties had occurred. On Task 1, the pre-test U of 7 ($p = .443$) and the post-test U of 2 ($p = .053$) did not fall in the critical region of U scores of less than or equal to 1 (p = .029). On task 2, the pre-test U of 7 (p = .443) and the Post test U of 3 (p = .100) also did not fall within the critical region. It was therefore concluded that the experimental group did not differ from the normal group on the auditory identification measure on either task at either pre- or post-test.

Subject M1 and Subject C2 each exhibited one /s/ related error each on pre-treatment measures. Subject M1 exhibited his error on Task 1 and Subject C2 exhibited his on Task 2. Both had all correct /s/ related judgments on post-test. The normal subjects exhibited no /s/ related errors in categorical perception.

Within treatment group comparisons revealed that both the cognitive group and the sensory motor group gained six points from pre- to post-treatment on Task 1. On Task 2, however, the cognitive subjects gained 13 points while the sensory motor subjects gained 5. The total gain then for the auditory identification measure by treatment group was 19 points for the cognitive subjects, and 11 points for the sensory motor subjects.

Results of 4IAX Auditory Discrimination Measure

Task One involved discrimination of singleton /s/ from the singleton stop plosive consonant in /CVCV/ structures, and Task Two involved discrimination of singleton /s/ from

/s/ clusters. A breakdown of the normal subject's scores may be found in Table 18. Each discrimination task was composed of twelve pairs of bisyllables. Each correct choice was worth one point with a maximum score of twelve points.

The normal children were tested on this measure only once. All four normal subjects achieved perfect scores on Task One. On Task two, two of the normal subjects achieved perfect scores, and two of the children missed one item each giving them scores of eleven out of the possible twelve points.

A breakdown of the experimental subject's scores is provided in Table 19. These subjects were tested on this task both pre- and post treatment with their respective scores provided accordingly. Visual inspection of Table 18 reveals that subject M2 had perfect scores on Task 1 both pre- and post treatment. Subjects C2 and M1 demonstrated improvement on post testing, and subject C1 exhibited no difference in his performance on Task 1 from pre- to post measures. Therefore on Task 1, two of the experimental subjects demonstrated improved responses on the post treatment measure and two subjects remained the same from pre- to post.

Table 18. 4IAX Discrimination: Normal Subject's Performance Results Expressed in Number of Correct Responses out of a Total of Twelve Items

	SUBJECT			
	N1	N2	N3	N4
Task 1	12	12	12	12
Task 2	11	12	12	11

Table 19. 4IAX Discrimination: Experimental Subject's Performance Results for Pre- and Post- Testing Expressed in Number Correct out of a Total of Twelve Items

	SUBJECT							
	C1		M1		C2		M2	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Task 1	8	8	10	12	11	12	12	12
Task 2	11	10	10	12	9	12	12	11

On Task 1, therefore at the pre-treatment point four normals and one experimental subject, Subject M2 had perfect scores of 12. At post-treatment, two additional experimental subjects had perfect scores of 12. Therefore, at the post-treatment point the subjects in the two groups performed the first task with no errors, except for one experimental subject C1, who did not change at all from pre to post treatment.

In Task 2, all four experimental subjects exhibited different scores from pre- to post measures. These subject's pre-treatment scores were compared to those of the normal subjects on this task. Three subjects demonstrated perfect scores, N2, N3, and M2. Three subjects exhibited scores of 11; Subjects N1, N4, and C1. These were followed by Subject M1 with a score of 9, and Subject C2 with a score of 9. On this task, two subjects, M1 and C2, demonstrated improved performance at the post treatment measure. Both Subject C1 and Subject M2 each exhibited a loss of one point from pre- to post measures.

Then at the end of treatment on Task 2, two experimental subjects had perfect scores as did the two normal subjects; one experimental subject had a score of 11 as did two of the normal subjects; and one experimental subject, Subject C1 had a score of 10.

The Mann Whitney U test was applied to determine whether or not the scores obtained by the subjects in the normal group were different from those in the experimental group (n1 = 4; n2 = 4; alpha = p. 05, one-tailed test). Ties were assigned the average of the ranks they would have had if no ties had occurred. On the 4IAX the U of 2 ($p = .057$) on Task 1, pre-test; and the U of 6 ($p = .343$) on the same task at post-test were not significant since the critical region of U scores less than or equal to 1 ($p = .029$). On Task 2, the pre-test U of 4 ($p = .171$) and the post test U of 7 ($p = .443$) also did not fall within the critical region. Therefore, it was concluded that the two groups did not differ on either pre-test or post-test performance on this measure.

Within treatment comparisons of the pre- to post treatment changes reveal then that on Task 1, the only change in the cognitive treatment subjects was that of the one point gain by subject C2, since C1's scores remained the same. Within the motor treatment subjects, the only gain on Task 1 was that of M1's two point gain, since M2's perfect score remained unchanged from pre- to post. On Task 2, subject C1 lost one point from pre- to post while subject C2 demonstrated a 3 point gain, giving the cognitive treatment subjects a net gain of two points. The motor treatment subjects demonstrated a net gain of one point since M1 gained two points while M2 lost one from pre- to post.

The only subjects who demonstrated gains on the 41AX discrimination measure were Subjects M1 and C2. Each demonstrated gains on each task from pre- to post treatment measures. They each totaled four point gains from pre- to post treatment across both tasks. Subjects C1 and M2 made no gains respectively from pre- to post treatment on Task 1, and each lost a point from pre- to post treatment on Task 2.

RESULTS OF ARTICULATION POST-TESTING OF EXPERIMENTAL SUBJECTS

Post test results on the *Templin Darley Test of Articulation*

Singleton Continuant Productions in Single Word Stimuli

A comparison of Table 20 with Table 4 will illustrate the substantially improved performance of all of the experimental subjects on test items containing the fricative singleton. Subject M1 demonstrated the greatest amount of improvement in terms of the number of test items improved. This subject improved performance on all continuants; improved productive performance on nineteen items by producing fricatives for these items whereas previously they were deleted or produced as stop consonants; corrected eighteen productions; Of the improvements made, six also reflected the production of final consonants which were deleted at pre-test.

Subject C1 also improved performance on all continuants; improved production on eighteen items by producing fricatives where he had previously deleted sounds or produced stop consonants; and corrected ten productions. Of his improved productions, eight included the production of final consonants which had previously been deletions. Of these eight, six were actually correct productions at post-test.

Subject M2 improved all her previously incorrect continuants ([g] and [v] productions were correct at pre-test). In all she exhibited fifteen improved productions at post-test. Ten of these were correct productions. Three previously deleted final consonants were improved. This subject produced [sk] in the stimulus word "dresses", though later on a substitute item, "kissing", she produced [s] correctly.

Subject C2 improved seven of his eight continuants which contained error productions at pre-test. Only his error productions of [ ] were unchanged at post-test. (This subject's family spoke Black English which may have affected the lack of change on this sound.) In all, this subject demonstrated eleven improved productions at post-test relative to pre-test performances. All eleven improvements were full corrections. Two of these improvements were corrected final consonants which had previously been deleted. Though this subject produced [t] for [s] on the stimulus item "dresses", on a substitute item "kissing", he produced [s] correctly.

Table 20. Experimental subject's response on Fricative stimuli on the __Templin Darley Test of Articulation__

	SUBJECT											
FRICATIVE	C1			M1			C2			M2		
Position in word	I	M	F	I	M	F	I	M	F	I	M	F
θ	st	s	s	*	–	*	*	–	f	t	f	f
ð	d	*	*	*	*	*	d	–	*	*	*	t
s	*	sd	*	*	*	*	*	t	*	*	sk	*
z	s	*	*	*	*	g	d	d	*	s	*	s
ʃ	*	st	*	*	*	ks	*	t	*	*	*	*
ʒ		z	dg		*	g		*	–		*	*
f	*	*	*	*	*	*	*	p	*	*	*	*
v	*		*	*		*	*		*	*		*

__NOTE__. * = Correct response; - = Sound omitted
Empty Spaces = fricative was not tested in that particular word position

__[s] Cluster Productions in Single Word Stimuli__.

Subject M1 produced eleven items correct at post-test. Subject C2 also produced eleven correct items at post-test. Subjects C1 and M2 produced ten correct items each.

As can be seen in comparing results as depicted in Table 21 with those in Table 5 in Chapter Two, every item across all four experimental subjects was improved except Subject C2's and Subject M1's pre-test productions of the [spl-] item. All subjects completely corrected eight of the same items on post-test. None of the experimental subjects produced correct three consonant [s] clusters. However with the two previously noted exceptions, all other three consonant productions contained [s] plus another consonant.

Table 21. Experimental subject's responses on the /s/ cluster subsection of the *Templin Darley Test of Articulation*

SUBJECT

Clusters	C1	M1	C2	M2
sm-	*	*	*	*
sn-	*	*	*	*
sp-	*	*	*	*
st-	*	*	*	*
sk-	*	*	*	*
sl-	s	*	*	*
sw-	*	*	*	*
spl-	sp	pl	p	sw
spr-	sp	sw	sw	sw
str-	st	sw	sw	sr
skr-	sk	saw	sk	sfr
-sm	*	*	*	*
-st	s	*	s	*
-sk	*	s	*	st
-ks	*	*	*	s
-mps	*	*	*	*

Note. * = Correct response; - = Sound omitted

Post-Test Results on the Weiner Phonological Process Analysis

In singleton continuants, Subject C1 corrected [s,v] productions at both word and phrase sentence level productions. Subject C1 corrected all [s] cluster productions at word level except word initial [sk-] cluster. However he did produce [s] instead of [sk-] whereas at pre-test he deleted both consonants. Phrase-Sentence level productions revealed diminished performance accuracy relative to word level performance as can be seen in Table 22 and Table 23. However Subject C1 did produce [s] in all clusters and all [s] cluster productions at phrase sentence level were improved over pre-test performance (Tables 24 and 25).

Subject M1. This subject demonstrated corrected productions of [s,f] and [v] at word level and produced a continuant substitution for [0] rather than a stop. All of these changes are improvements over his pre-test performances (Tables 6 and 7). His performance at sentence level was consistent with that at the word level and also revealed improved performance in all continuants over his pre-treatment performance.

In post-test [s] cluster performance in the PPA at word level, only one error remained. Subject M1's production of one instance of word final [-sk] was reduced to a stop. This cluster was correct at the other word level test item and on both items at phrase-sentence level. Only one error remained at phrase-sentence level and that was one instance of [s] for word final [-st]. All of this subject's performance at post-test represented improvement over pre-test performance (Tables 8 and 9).

Table 22. Experimental subject's responses on the single word stimuli on the Stopping for Continuants section of the *Weiner Phonological Process Analysis*

SUBJECT

CONTINUANT	C1	M1	C2	M2
s-	*	*	*	*
s-	*	*	*	*
f-	*	*	*	*
-f	*	*	*	*
v-	*	*	*	*
v-	*	*	b	*
-v-	*	*	*	*
-0	-	f	f	*

Note. * = Correct response; - = Sound omitted

Table 23. Experimental subject's responses on the sentence recall items on the Stopping for Continuants section of the *Weiner Phonological Process Analysis*

SUBJECT

CONTINUANT	C1	M1	C2	M2
s-	*	*	*	*
s-	*	*	*	*
f-	*	*	*	*
-f	*	*	*	*
v-	*	*	b	*
v-	*	*	b	*
-v-	*	*	*	*
-0	-	f	f	*

Note. * = Correct response; - = Sound omitted

Table 24. Experimental subject's responses on the Cluster Reduction (initial and final /s/ clusters) section of the _Weiner Phonological Process Analysis_, single word items

	SUBJECT			
/s/ CLUSTER	C1	M1	C2	M2
sk-	*	*	*	*
st-	*	*	*	*
sl-	sh	*	*	*
sl-	sh	*	*	*
sw-	*	*	*	*
sw-	*	*	*	*
sn-	*	*	*	*
sm-	*	*	*	*
-st	*	*	s	-
-st	*	*	s	*
-sk	s	k	ks	st
-sk	s	*	s	st

Note. * = Correct response; - = Sound omitted

Table 25. Experimental subject's responses on the Cluster Reduction (initial and final /s/ clusters) section of the _Weiner Phonological Process Analysis_; sentence recall

	SUBJECT			
/s/ CLUSTER	C1	M1	C2	M2
sk-	*	*	*	k
st-	*	*	*	*
sl-	st	*	*	*
sl-	s	s	s	*
sw-	*	*	*	*
sw-	*	*	*	fw
sn-	*	*	*	*
sm-	*	*	*	*
-st	s	s	s	s
-st	s	*	s	*
-sk	s	*	ks	st
-sk	s	*	s	s

Note. * = Correct response

Subject C2. This subject corrected his performance in [s,f] and [v] productions at word level relative to pre-treatment performance. One instance of [b/v] occurred at word level. This subject produced a continuant for [θ] instead of a stop consonant as he previously did. This subject's post-test performance at phrase-sentence level was consistent with word level performance, except that both instances of word initial [v] were produced as [b]'s. This subject therefore demonstrated improved performance in all continuant singletons at post-test, with exception of [v] at the phrase-singleton level.

In [s] cluster performance this subject demonstrated improvement in every item tested. Word level and phrase-sentence level production were consistent with each other. All word final [s] clusters tested were improved over pre-test performance, however, most were reduced to [s].

Subject M2. Subject M2 demonstrated correct productions in both [s] and [θ]. These were improvements over pre-test performance. The [f] and [v] productions were correct at pre-treatment. Performance was consistent between word level and phrase-sentence level performance.

On [s] cluster performance at post-test, this subject demonstrated improved performance on all items at phrase-sentence and all but one instance of word final [-st] at word level. One instance of correct production at pre-test on [sl-] occurred, though upon being asked to repeat the item at that time, Subject M2 produced a [hl-]. However, at post-test this item was produced as [sl-]. This item is considered by the investigator to have been improved at post-test based on this subject's performance in treatment sessions. All of this subject's word initial [s] cluster were corrected at post-test.

INDIVIDUAL SUBJECT CHARACTERISTICS

Additional Assessment of Experimental Subject's Respective Language Abilities

The performance of each subject on the Test of Early Language Development (TELD) administered during the initial assessment battery prior to treatment is provided in Table 26. As noted in Chapter Two this test is considered as a broad based language screening instrument which assesses language comprehension and expression relative to the areas of linguistic form and content. Its primary purpose is to be used in the identification of children who require further in-depth language assessment. All four experimental subjects scored within the "Average" range for age (average range is any language quotient (LQ) falling between a score of 85 and 115) and all were within one standard deviation of the mean on their respective T-scores

Table 26. Individual Experimental Subject's Performance on the Test of Early Language Development

	SUBJECT			
	C1	M1	C2	M2
Language Quotient	97	98	101	91
Percentile	40	46	52	29
T-Score	47	47	50	43
L-Age	46 Mos	63 Mos	69 Mos	50 Mos

(mean =50; SD=10). Based on the results of this instrument alone there would not have been an indication to pursue further language assessment on any of these subjects.

The Carrow Elicited Language Inventory (CELI) was used in the initial assessment battery as a standard response elicitation technique to obtain expressive language structures in each of the subjects following an intelligible model. This instrument was standardized on white middle class children and was therefore not appropriate for all of the subjects in this study for normal clinical assessment purposes. It was used only so that these four subject's respective expressive language performance might be compared to whatever extent possible on the same task. As with other standardized measures of this kind, (sentence repetition) interpretation of the results for children exhibiting severe articulation problems is not possible under standardized conditions. This is due to the difficulty in ascertaining intended morphological targets in the child's actual utterance as a result of unintelligibility. Utterances were transcribed phonetically from audiotapes of the subjects' performance on this instrument.

Misarticulation patterns on the part of each subject resulted in numerous grammatical forms which could not be scored. The presence of contrastive forms, such as a singular noun and its plural form, in which a child varies his production due to the form change allows the examiner to determine whether or not the child is at least marking the grammatical form to indicate he knows its different. There were only four nouns which occurred in both singular and plural form on the CELI. All had plurals forms with a [z] or [z]. "House" was one of these nouns. Three of the four subjects marked this noun differently in singular and plural forms. Subject M1 produced "house" as [auk], and "houses" as [auke]; Subject M2 produced the same forms as [hau] and [hauke] respectively; and Subject C2 as [au] and [aude], respectively. Subject C1 did not produce any variations of singular vs plural nouns. It may be seen from Table 27 that this subject exhibited the most immature syntactic patterns of any of the experimental subjects on the CELI. This was also evident in his spontaneous language as exhibited over time in the treatment sessions.

Table 27. Experimental Subject's Performance Results on the Carrow Elicited Language Inventory

GRAMMATICAL CATEGORY	C1			M1			C2			M2		
	S	E	%	S	E	%	S	E	%	S	E	%
Articles (41)	40	39	-	41	29	21	0	-	-	41	2	23
Adjectives (7)	7	0	100	7	0	100	7	0	100	7	0	100
Nouns Singular (50)	50	2	8	50	1	23	50	0	100	50	0	100
Nouns Plural (9)	0	-	-	0	-	-	4	0	-	4	0	-
Pronouns (41)	35	14	-	41	2	52	41	1	78	41	4	13
Verbs (103)	82	46	-	88	9	-	91	1	-	83	5	-
Negatives (13)	5	1	-	6	0	-	13	1	32	13	0	100
Adverbs (9)	9	0	100	9	2	65	9	2	100	9	0	100
Prepos-itions (14)	14	3	4	14	2	6	14	0	100	14	0	100
Demostra-tions (2)	2	1	9	2	0	100	2	1	7	2	0	100
Conjunc-tions (7)	7	4	21	7	1	49	7	1	49	7	0	100

SUBJECT spans C1–M2.

<u>Note</u>. S = Number of Scorable Responses; E = Number of Errors; % = Percentile Rank; Numbers in Parentheses reflect total number in a category; - = Not Available.

Regular verb past tense forms were generally unscorable in all four subjects as were the noun plurals ending in voiceless consonants followed by [s]. Therefore for the purposes of this investigation, each subject's performance was scored according to the number of scorable responses available on each. The scores then, as noted in Table 27, are provided only for visual comparison purposes. When all of the responses in a grammatical category were scorable, a percentile rank could be determined. These are also available in Table 27. Expressive language problems in terms of morphologic/syntactic errors are not uncommon in young children exhibiting unintelligible speech.

Description of the Experimental Subject Pairs

The first experimental pair was composed of two Caucasian males, one being the 4 year 3 month old and the other, 5 years 4 months. The younger child lived in a rural area located 75 miles north of Beaumont, Texas. The older male was from a small town located approximately 20 miles south of Beaumont. These two children were from similar backgrounds relative to parental education levels (high school graduates); both parents were employed full time outside of their respective homes and both boys were cared for by their grandmothers during the day. The younger subject in this pair attended a daily half-day pre-school during the school year, while the older one was enrolled in daily half day kindergarten. Each subject was an only child. In terms of developmental history, the older subject's was unremarkable while the younger subject had received bilateral P.E. tubes at the age of two and has had them since that time. His hearing was monitored regularly during the investigation to ensure that it remained normal.

Testing was accomplished over a protracted period of sessions for the younger child as he required frequent reminders to attend to and complete the various tests. Additionally some of the procedures developed for the investigation such as the auditory discrimination task required skills that he had not yet developed on a stable basis. For example, the auditory discrimination task described in Chapter Two required that the child point to the puppet that "said two words that were not the same". This child learned how to perform according to the directions on real word combinations like Mom-Dad vs. Mom-Mom; and then progressed to nonsense syllables containing plosives and vowels, like /bo-bo/ vs. /bo-po/. Both subjects required frequent prompts and reminders to stay on task to complete the baseline probes for word and spontaneous speech productions.

The older male subject was assigned to the sensory motor approach through the toss of a coin, and has been referred to throughout the study as Subject M1. The other child was then assigned to the cognitive approach and has been referred to as Subject C1. Subject M1 was seen three times a week and Subject C1 was seen twice a week for individual 30-40 minute sessions. Subject C1's reduced schedule resulted from the distance involved to get to the treatment session and family work schedules. Once school was out he came three times a week. Each subject was accompanied to his treatment sessions by the grandmother who kept him when not in school during the day. Both subjects in the first experimental pair were seen in the investigator's office for all treatment sessions.

Both boys in pair one exhibited significant resistance to the particular demands of the investigation regarding both the probe tasks/instruments and the treatment portion of the sessions as well. As noted in the second chapter, each child was required to wear a cowboy hat that supported the microphone at a stable distance and location relative to the child's mouth. The resistance behaviors exhibited by both children were overt and often verbally explicit. At times each refused to wear the hat; refused to speak to carry out the probe task; made statements like "I want to go home"; "I hate this"; or "I don't want to do this", etc. Even when either subject was wearing the head set and participating in the task, the investigator spent a great deal of time in both boys' earlier sessions encouraging each to comply with the demands of the task. Compliance was increased with visual reinforcers such as colored plastic chips which each subject was allowed to drop in a bank for each attempt. Nevertheless, the probes for both boys were quite irregular during the early sessions, specifically due to their overtly resistive behaviors, as often the children were so upset for so long a period that the probe simply couldn't be accomplished in the manner intended. The investigator allowed a series of sessions to occur between probes early on in order to help each child develop successful interaction patterns that would result in decreased resistance. This alteration of the proscribed sequence of probing occurred before their 25% production accuracy level in either the word or spontaneous probes.

Both boys were highly expressive in terms of quantity of verbal output during most of these sessions, but each often used talking in apparent attempts to control the content or procedures involved in the tasks and this type of behavior was also disruptive to the probe process, and the subsequent treatment portion of the session. Subject M1 exhibited frequent overt avoidance or rejection of the probe task, either by explicit verbal statements or in simply refusing to participate. Subject C1 was prone to talk without allowing the investigator to have a turn, demonstrating what is referred to pragmatically as "floorholding". Subject C1 would often approach the probe or interrupt it by relating some incident of personal importance, in detail, and when the investigator attempted to direct him to the task he would often get louder and persist in his speaking saying "let me tell you something...". Children with severe communication problems often exhibit difficulties in behavioral control/appropriateness. It is realized that the "behavior problems" referred to above were not necessarily perceived as problems in the boys' respective home environments. Interruption of family members and verbal demands of family members as well as explicit verbal refusal to family member requests/directives often went unchallenged by the accompanying adult. These behaviors were also reported by subject C1's pre-school teacher at school.

The two children in the second experimental pair were the female who was 5 years 2 months old and the other 5 year 4 month old male. Both of these subjects were black, and were enrolled in the Beaumont Independent School District's combined Head Start- Pre Kindergarten Program at the time of their participation in the study. Both children lived in Beaumont, Texas. The female subject lived with her mother and older sister, her father being deceased. The mother of this child did not work outside of her home. The male subject lived with his parents and younger sister. The father of this subject was employed. All parents had high school educations. Each of the subjects in the second pair had unremarkable developmental histories.

The male was assigned to the Cognitive approach by the flip of a coin, and the female subject was then assigned to the sensory motor approach. He has been referred to as subject C2 and she, as subject M2.

The two children in the second experimental pair differed significantly from those in the first experimental pair in regard to their behavior in the treatment sessions. Each of these children went through the initial testing phase, probe tasks, and treatment sessions until completed without a single occurrence of a verbal refusal, or overt rejection of a task. Each attempted tasks as presented. Each would tell the investigator "I don't know" on occasion in response to a question posed. Subject M2 cried on two occasions during the treatment portion of two sessions; her crying appeared to be due to anxiety over being able to make a correct response. Both of these children differed from the first experimental pair also in that they did not initiate conversation or otherwise engage in spontaneous speech in the quantity that the other children did, early on. Even toward the end of their treatment sessions these subjects still did not demonstrate the type of spontaneity observed in the first pair. Subject M2 did however, initiate conversation freely after she had been attending the sessions for awhile, though the quantity of her output was still reduced in comparison to the first pair. Both children were described by their respective classroom teachers as well-behaved. Neither subject was observed to interrupt family members in the presence of the investigator except on one occasion in which Subject C2 interrupted his mother once during conversation with the investigator. Subject C2 was quite verbal and spontaneous in the presence of his parents and initiated conversation easily with them. Both the parents of subject C2 and the mother of subject M2 explicitly expressed verbal expectations relative to their child's conduct in the session on several occasions in the investigator's presence.

The children in the second experimental pair were seen at school in the room normally occupied by the speech-language pathologist. There was considerably more ambient noise in the school setting than in the investigator's office. Once school was out however, the children in the second pair were brought to the investigator's office by their respective parents. The children in the second pair were seen three times a week for thirty-forty minute sessions. The subjects in the second pair were accompanied by a parent in all sessions once school was out, and in a number of sessions prior to that time.

Information has been provided on all of the experimental subjects in terms of pre-treatment articulation ability; language comprehension and expression, general intellectual functioning; familial; developmental; and hearing ability. This last section also presented general behavioral observations on the four experimental subjects. The behavioral aspects could also have been viewed from a language pragmatics perspective to a large extent.

CHAPTER IV

DISCUSSION

The present study was designed to address several issues relative to the nature and treatment of misarticulation in pre-school children. Overall, this study compared two theoretical perspectives concerning the nature of misarticulation by investigating learning rate differences in misarticulating children under treatment approaches reflecting the different perspectives. The experimental subjects exhibited the same pattern of misarticulation. One approach was a cognitive approach and the other was a more traditional sensory-motor approach. Related issues under investigation included questions regarding whether or not sensory motor differences were evidenced between pre-school /s/ misarticulators and normally articulating children of the same age on measures of /s/ duration; and whether or not differences were evidenced between normal children and the /s/ misarticulating children in the ability to perceptually categorize their error sounds in tasks involving stop/continuancy contrasts.

The experimental subjects in this investigation exhibited a misarticulation pattern referred to as "stopping for continuancy" involving fricatives and in particular /s/. They also exhibited "cluster reduction" which in the case of /s/ + stop clusters resulted in the cluster being reduced to only the stop consonant by the deletion of the continuant /s/. Both of these terms reflect the phonological process orientation. Cognitive level constraints and operations were discussed in Chapter One relative to a cognitive model which attempted to account for the presence of such "phonological processes". In traditional terms, the subjects "substituted" a stop consonant for a fricative and deleted the fricative in /sC/ clusters. Motor level output explanations were also discussed relative to a motor model which attempted to account for misarticulation.

It was assumed that the results of the investigation would provide for a better way to account for the nature of the articulation differences in children who articulated /s/ normally and those who produced the stop consonants "in place" of /s/. Additionally, the results of the treatment comparison were expected to provide information on learning differences relative to treatment type. This investigation examined the misarticulating subjects for differences relative to the normals at three different points in time; pre-treatment, a level of 50% accuracy of production; and a terminal level of /s/ production proficiency. Learning differences relative to treatment type were examined at the last two points in time. Discussion proceeds relative to these three points in time as well as an initial treatment stage, which corresponds to the period of time between pre-treatment and the 50% production accuracy level. It was felt that whatever differences existed prior to treatment might be more clearly understood by viewing further changes as a result of intervention over time. Information obtained on learning patterns that were evidenced by the different subjects in the different treatment approaches would further enhance the understanding of the nature of any differences at the outset of treatment, and, it was hoped provide relevant theoretical insights as well as indications for treatment considerations for this pattern of misarticulation. The discussion will now proceed relative to the four points in time.

PRETREATMENT COMPARISONS

Sensory motor differences were evidenced by the experimental subjects relative to the normal subjects in several ways at the pre-treatment point. The vowel to vowel measure used at pre-treatment with both normals and experimental subjects was based on spectrograhic measures of duration extending from the termination of the vowel preceding the consonant to the beginning of the vowel following the consonant. For the misarticulators who produced stops for the continuant [s] singleton and stops in place of the [s] + stop clusters this interval contained the silent closure period, the burst, and the release period across both phonemic contexts. The phonemic contexts examined for both groups for comparison included intervocalic /s/ singletons and intervocalic /s/ + stop clusters. Additionally, the misarticulator's intervocalic intended stop singletons were measured for duration for within group comparison.

First, in terms of absolute mean duration differences, the experimental subjects demonstrated longer mean durations on their [s] singleton environments than the normals, as evidenced in that none of the experimental subject's individual mean durations overlapped any of the normal subject's individual mean durations in across group ranking of mean durations. Secondly, intrasubject variability was greater for the experimental subjects than for the normal subjects.

If the misarticulators were attempting to produce stops for [s], their mean vowel to vowel durations should have been shorter than the normal subject's [s] mean durations, instead of being longer. In fact, the experimental subject's mean durations for intended stops at pre-treatment were all shorter than three of their own mean durations for [s] singletons. Three of the subjects demonstrated longer mean durations respectively for their [s] singletons than for their own known intended stop consonants. One of the experimental subjects, C2, did not differentiate intended stops from [s] singletons in terms of mean duration. Why then, would three of the experimental subjects demonstrate longer mean durations for "stop" consonants produced "in place" of [s]? The trend across the three experimental subjects who effected duration differences between their known intended stops, and what would be assumed to be other "intended stops" would not be explained on the basis of reduced motor speech capabilities as suggested by Weismer and Elbert (1982). These differences could be explained if the misarticulators weren't attempting to produce only stop consonant targets in place of [s]; but were in fact, attempting through the manipulation of articulation gestures to intentionally effect duration differences to represent different targets.

An indication from this then would be that the three subjects were motorically effecting the intended continuant /s/ characteristic of duration, which might have been the only surface feature attributed to /s/ at this point. The duration distinction was imperceptible to the investigator for transcription purposes but was observable spectrographically. This type of phenomenon has been reported in several studies in which children have been found to demonstrate acoustic contrasts which were imperceptible to adult listeners, and therefore were not represented in transcription, but which were revealed through spectrographic analyses (Macken and Barton, 1980; Weismer, Dinnsen, and Elbert, 1981). In the Weismer, Dinnsen and Elbert study for example, word final consonants which were perceived as absent were marked appropriately by the duration characteristics of the vowel which preceded the "missing" consonant. Weismer et al have interpreted their findings as evidence of some knowledge of the word final consonant. Based on Subject C2's pretreatment performance relative to mean duration, it is possible that he did not attempt to effect any duration differences across the phonemically different contexts, since he exhibited essentially identical means for both his intended stops and the [s] singleton environments.

Why then would the misarticulators demonstrate longer and more variable mean durations for the [s] singleton environments rather than durations which were in fact similar to the normals? Weismer and Elbert (1982) interpreted their findings regarding differences in mean duration and relative intrasubject variability between normal subjects and subjects who misarticulated /s/ to be due to motor control difficulties. An alternative suggestion is that these duration differences may have been due to cognitive level mechanisms. If, for example, the experimental subjects were at that developmental point in time in the early stages of organizing their respective /s/ feature sets, then differences of the type indicated by the experimental subjects across the different phonemic contexts in this study would be expected to occur. In other words, it might be assumed on the basis of the data that three of the four experimental subjects were indicating production distinctions of the feature of duration. There was no indication of frication in the pretreatment spectrograms, though they have not been systematically studied for the presence of frication at this point in time. If these subjects "knew" that /s/'s are longer than stops, but had not at that point developed stable feature values for /s/, then it would be expected that these subject's [s] productions would be more variable and diffferent in duration from children producing [s] normally. These differences, however, would not be due to a lack of motor control, rather they would be due to the subject's unstable duration values relative to /s/. These unstable duration values are part of the subject's cognitive level organizaton of /s/. Additionally, since three of the experimental subjects evidenced differences between stops and fricatives on the basis of mean duration it would seem that their respective motor systems were more controlled than less so.

If the duration differences were in fact an intentional marking of the continuance aspect of [s], then the misarticulator's [s] cluster mean durations would also reflect the duration difference. In fact, all four experimental subjects exhibited mean [s] cluster vowel to vowel durations which were longer than their intended stops. There was no overlapping of the experimental subject's mean durations for intended stops and [s] clusters, which at pre-treatment were perceived by the adult listener as stops. If the experimental subjects were in fact deleting or omitting [s] in the /s/ + stop clusters and reducing the cluster to a stop, due to lack of awareness of the continuance aspect, then their intended stop durations and their error stops for [s] + stop cluster mean durations should have been similar. Additionally, the individual consonants within a cluster are generally of shorter duration than they would be if produced as singletons (Weismer, 1984). Therefore, it would seem even less likely that the "stops" occurring in place of the clusters were intended only for the stop portion of the clusters. Feature coalescence in cluster reduction has been reported in normally articulating children by Greenlee (1974) and in cluster reducing misarticulators by Hoffman and Damico (1988). In both of those studies, the stops which occurred in place of the cluster were different from the stop original to the cluster, but they contained elements of both the elements in the cluster. In the present investigation, the stops which the misarticulators used were original to the cluster, indicating that the only feature marking was that of duration. Reporting on the same type of cluster reduction evidenced in the present investigation, Weismer (1984) provided anecdotal evidence on one seven year old whose cluster obstruent intervals were 60 ms longer than the singleton obstruent intervals.

A third pre-treatment sensory motor difference relative to the normal's performances was demonstrated by the experimental subjects in terms of relative duration differences between [s] singletons and [s] clusters. All four normal subjects demonstrated longer mean durations for their respective [s] cluster environments than for their [s] singletons, with no overlapping means across these two measures. The situation with the experimental subjects at pre-treatment was that on the basis of the absolute values of their respective means across the two measures, their [s] clusters were not longer than their [s] singletons. Additionally, three of the experimental subject's [s] cluster means were shorter than three of the [s] singleton means in the experimental group. Despite this fact there was considerable overlapping of means across these two phonemically different contexts for the experimental subjects, primarily due to the fact that C2's [s] singleton mean duration represented the shortest duration, while C1's [s] cluster mean duration represented the longest duration across the two sets of measures. The overlapping means indicated that the performance on the two measures by this group was similar, though visual inspection revealed that three of the experimental subject's mean durations for [s] clusters were shorter than three of their /s/ singletons. On an intrasubject basis, two of the subject's /s/ cluster means were shorter than their respective singletons, while two exhibited the reverse.

Across group ranking procedures revealed a sensory motor similarity between the normal subjects and experimental subjects on their respective [s] cluster performances. This similarity was due to the fact that three of the experimental subject's mean [s] cluster durations fell at the lower end of the normal subjects' mean [s] cluster range. This comparison then is one of absolute mean values. As previously mentioned, visual inspection revealed that all of the experimental subject's intended stop means were shorter than all of their own [s] cluster means but not their [s] singleton means; three of the [s] cluster means were shorter than three of the [s] singleton means. It would be expected that if the misarticulators had organized complete feature sets for the stop consonants sampled and had demonstrated motor proficiency in the production of those stops, while they had only organized partial feature knowledge of the continuant /s/ which was exemplified by subsequent motor production of this partial distinction for /s/, then stop consonant vs /s/ contrasts; and stop consonant vs /s/

+ stop cluster contrasts would be more distinct than /s/ vs /s/ + stop cluster contrasts.

Weismer (1984) has hypothesized that in the case of misarticulators who stop for [s], in the event the stop is not just a substitute for a fricative, that acoustic evidence in the way of spirantization arising from difficulty in controlling precision of constriction during the closure interval, or a slower release of the constriction, may be present as evidence of knowledge of the fricative component in [s]. Duration was the only measure of interest in the present investigation at its outset. However, the duration differences and relationships observed, both in the comparisons of the misarticulators to the normals and to themselves across different phonemic contexts, suggest that in future research further analysis of the data for specific mechanisms by which these duration differences were effected would be helpful in understanding the nature of the misarticulations. Specification of the mechanisms used to effect the duration differences are indicated on an intrasubject basis over the course of treatment. It is not known how knowledge of parts of a consonant's feature specifications for production would be handled between the cognitive and motor levels.

Perceptual Abilities of the Misarticulating Subjects

Auditory perceptual testing on word identification tasks in which /s/ was first contrasted in initial word position with word initial /t/ and /k/ and then contrasted in word final position with word final /t/ and /k/ revealed that the misarticulating subjects performed in a similar manner to the normal subjects on these measures. The two groups also performed in a similar manner on auditory discrimination tasks in which /s/ singleton was contrasted with singleton /t/ and in which /s/ clusters were contrasted with /s/ singletons and /t/ singletons. The lack of differences was substantiated statistically, as well as by visual inspection which revealed that both groups had overlapping scores on all measures.

Perceptual task performances of misarticulating subjects were compared with their respective production performances at pre-treatment. On the auditory identification task which tested identification of the stop/continuance contrasts in word initial position, all four of the misarticulators achieved perfect scores. This finding indicated that they performed in a similar manner to the normal subjects. In the previous discussion concerning pre-treatment sensory motor measures, it was evident that three of the experimental subjects had productively distinguished the stop/continuance contrast by manipulating duration for the contrast in word initial position. It is possible that these same three individuals M1, C1, and M2 made their perceptual decisions based on similar limited information of the contrast. Hoffman and Damico (1988) reported feature based perceptual performance in their investigation of the identification and production of /sk/ clusters in children who inconsistently reduced /s/ + C clusters. Subject C2 however, exhibited the same perfect score on the auditory identification task just mentioned, though he did not effect duration differences between the word initial singleton /s/ and /t/. Disparate perception/production performance was also reported by Hoffman and Damico, and they suggested that the misarticulators in their study might be constructing two underlying representations for each word. The children in the present study did not produce the words on their auditory perceptual tasks however, like those in the Hoffman and Damico study. In order to develop a better understanding of the relationship between perception and production in the misarticulators in the present study, further spectrographic analysis of how each child accomplishes the duration changes over time is indicated.

At pre-treatment, the experimental subjects exhibited performance similiar to that of normal subjects in auditory perception tasks involving the stop/continuance contrast.

However, the experimental subjects differed from the normal subjects on a number of speech production measures in terms of absolute mean duration differences, intrasubject variability, and within group relationships on duration differences relative to certain phonemically different contexts. These differences on the surface might suggest a difference in motor speech skills between the two groups, however, an alternative explanation is that the differences though manifested through measureable motor differences appear to be cognitive in origin. If the experimental subjects were in fact still in the process of organizing the features for /s/ but not yet correct in the set of features their [s] productions contained, their output representations might be reflecting their cognitive level errors more than true deficiencies or differences due exclusively to the motor system itself.

INITIAL STAGE OF TREATMENT

In attempting to account for the more accurate theory to explain the misarticulator's differences and relative progress, discussion will focus now on the point in time that each experimental subject attained a minimal production accuracy level in [s] production. The expanse of time encompassed in the initial stage was different for each subject and involved the time period during which each subject attained minimal production accuracy (25%) of [s] but prior to the 50% accuracy of production level.

Relative Timing of Attainment of A Minimum Production Accuracy Level in Single Words and Connected Speech

A minimum production accuracy level of 25% correct was noted for each subject at both the single word and connected speech levels, and was used to establish a "starting point" of accurate production, compared to the terminal criterion at which point remediation of [s] was considered complete for the purposes of this investigation. All measures of percentage of accuracy were derived from performance on the single word or connected speech probes. For single word production, it was reported that Subject C1 attained a minimal production accuracy level of 25% correct on the 16th session. Subject C2 attained the same level on his 21st treatment session; Subject M2 on the 22nd treatment session, and Subject M1 on the 44th treatment session. The cognitive approach subjects were the first to attain this criterion then, though it is obvious that there was a clear difference (28 sessions) in the first treatment pair, while the difference is not at all clear for the second. What is more interesting about the relative timing demonstrated by these four subjects in attaining a minimal accuracy of production level in single word production is what was suggested about the role of "practice" or drill in articulation remediation in the experimental subjects at this point in their respective treatment progressions. Under the sensory motor approach assumptions, the relatively early attainment of minimum production accuracy by Subjects C1 and C2 would not have been predicted. The significance of how the two cognitive subjects performed relative to the sensory motor pair is not in the actual amount of time lead, but in the fact that they did not achieve this criterion later than the sensory motor subjects.

In regard to attainment of a minimum accuracy of production level across both the single word level and connected speech in this investigation, the four experimental subjects performed in a similar manner regardless of the differences in their respective approaches. The same minimal production accuracy level was achieved in connected speech as in words within two consecutive sessions for Subject C1 and within five sessions for Subject C2. Subject M1 attained this level in connected speech within two sessions of attaining it in single words and Subject M2 attained it within four sessions. Facilitation of learning transfer has often been emphasized in "sequencing instruction steps from simple to more complex behaviors (Bernthal and Bankson, 1981, p. 265)." Progressive levels of difficulty in terms of increasing length and structural complexity have been emphasized in a number of traditional remediation approaches (Van Riper, 1939; McDonald, 1974; Johnson, Goldberg, and Mathers, 1984). The role of practice in articulation treatment has been stressed in remediation programs in which the motor skill aspects of speech are emphasized (Ruscello, 1984). The relative timing of minimal production accuracy levels at both the single word level and the connected speech level across the misarticulators did not support any relative advantage of the progressive stage model of the sensory motor approach at this point in treatment. Further, this finding also failed to support the advantage of greater amounts of response practice in treatment experienced by the sensory motor approach subjects in the present study, which was 5-6 times the amount experienced by the cognitive approach subjects.

Learning Patterns

In chapter 3 it was reported that there were two different learning patterns observed in the experimental subjects relative to attaining minimal production accuracy level in connected speech, which is the level of greatest clinical importance. Subject C1 had attained his minimal production accuracy level in connected speech in the first quarter of his treatment progression, whereas the remaining three subjects had progressed through at least one half of their respective treatment progressions before attaining their respective minimal accuracy of production levels. Discussion on learning patterns will continue in the discussion on attainment of final criterion, at which time a broader perspective on learning patterns over the entire course of treatment for each child will be presented.

Syllable Shape Emergence

Results on lexical/syllable shape emergence provided more information for the development of an accurate explanatory theory regarding the nature of misarticulation in the experimental subjects. All four experimental subjects exhibited the emergence of the /-Vs/ lexical/syllable shape as the first shape to reach the minimal production accuracy level, despite the fact that all subjects experienced the /sV-/ shape first in treatment. At the time Subjects M1 and C1 attained the minimum accuracy level on /-Vs/ they exhibited no other lexical shapes containing /s/ in their productions. At the time Subjects M2 and C2 attained their respective minimum level on /-Vs/ each had exhibited a single word initial /s/ production; M2 on an /sV-/ lexical and C2 on an /sCV-/ lexical shape. All four subjects also exhibited the /-Vs/ lexical syllable shape first at the minimal accuracy level in connected speech.

The emergence of the word final /s/ form in the /-Vs/ lexical shapes may be related to the presence of position constraints which only allowed word final /s/ words in the lexicon (Dinnsen, 1984; Elbert and Gierut, 1986). However, if this is so, to what extent must the phonological organization of a phoneme's feature set be evidenced in production before the resulting sound production may be considered to be included in such a constraint. For example, if the misarticulator's were evidencing /s/ knowledge at pre-treatment in their duration distinctions, was that feature sufficient to indicate that there was no position constraint operating in word initial position? Dinnsen (1984) has suggested that the systematic nature of such a behavior must be indicated to make assumptions about the nature of the child's underlying representations. Nevertheless, in the case of M1 there was no evidence of any correct /sV-/ productions until thirteen word probes later; for C1 it was ten word probes later. Factors other than position constaints previously cited in the literature suggest a cognitive level origin for the development of certain lexical shapes over others. Schwartz and Leonard (1982) found that children are more likely to produce words with characteristics simiiliar to their phonological knowledge, both immitatively and non-immitatively, earlier and with fewer presentations than words with characteristics inconsistent with their phonologies

(p. 330). They interpreted this finding as further evidence that children actively select the word forms they produce to the exclusion of others.

It is also possible that even though they appeared to mark word initial /s/ duration related differences in their pre-treatment productions, they were unable to produce auditorially perceptible [s]'s in the word initial position due to motor level difficulties in either coordinating or executing the feature combinations necessary in that sequence of sounds. Kent has observed that sounds in final position are only minimally influenced by coarticulatory factors, compared to initial consonants (Kent, 1982). Netsell (1981) in describing the developmental acquisition of speech motor control noted that up until about 24 months the child is working primarily on the development of "spatial" goals (placement, shaping or movement components which yield the acoustic patterns to approximate his models). Netsell suggested that from 1-6 years following that developmental period, the child is working to coordinate his temporal aspects of speech production with his spatial goals, in a spatial-temporal period, and this period is overlapped and succeeded by the temporal period (p. 152).

COMPARISONS RELATIVE TO THE EXPERIMENTAL SUBJECTS' SENSORY MOTOR PERFORMANCE AT THE 50% ACCURACY OF PRODUCTION LEVEL

Comparison of Performance on the Vowel to Vowel Measures

The experimental subjects exhibited sensory motor differences relative to the normal subjects at the 50% accuracy of performance level on both /s/ singleton and /s/ cluster measures. First, the experimental subjects exhibited longer mean vowel to vowel durations for /s/ singleton environments than the normal subjects at their respective 50% production accuracy levels in that there were no overlapping means. Second, three of the experimental subjects also exhibited greater relative intrasubject variability. The experimental subjects demostrated greater within group relative variability as well.

A third sensory motor difference evidenced on this measure was that the experimental subject's respective performances on the /s/ cluster vowel to vowel mean durations were longer than the normal subject's as well. Fourth, the experimental subject's relative intrasubject variability was at least twice times that of the normal subject's variability. Within group relative variability was also greater on this measure for the experimental subjects compared to the normal subjects.

In terms of treatment differences apparent at this point for /s/ singleton environments Subject M2 was the only subject whose duration measures were changing in a normal direction. This subject decreased her mean and intrasubject variability at the 50% production accuracy level, while Subject M1 along with Subjects C1 and C2 increased their respective means. Subject M1 and Subject C2 also increased intrasubject variability, while Subject C1 decreased intrasubject variability. On the /s/ cluster measure, all of the experimental subjects exhibited increased mean durations, with only one subject indicating a reduction in intrasubject variability, Subject C1. Subject M2's improved performance on the /s/ singleton vowel to vowel measure was consistent with sensory motor expectations, however, due to M1's performance, interpretation of these results is difficult.

In terms of absolute mean duration differences then the normals and the experimental subjects differed on vowel to vowel duration measures at the 50% accuracy of production point. However, in contrast to their pre-treatment status, the experimental subjects were exhibiting the same duration relationship between their clusters and singletons as the normal subjects on this measure, i.e. longer cluster mean durations than singletons.

Comparison of Performance on the [s] Duration Measures

The [s] duration measures were only made at the mid and post-treatment points, when [s] production was perceptibly evident in the experimental subject's productions. It was reported in Chapter Three that the within group ranking on this measure was the same from the 50% accuracy of production point to the post-treatment measurement point. On the [s] duration measure, once again sensory motor differences were revealed between normal subjects and the experimental subjects. First, at the 50% accuracy of production point, the experimental subjects exhibited longer mean [s] singleton durations than the normals, with non-overlapping means occurring between the two sets of subjects. Second, within group relative variability was greater for the experimental subjects than for the normal subjects on this measure. Third, the experimental subjects also demonstrated longer mean [s] durations for /s/ clusters than the normal subjects, and once again there were no overlapping means between the two sets of subjects.

At the 50% production level the two sensory motor subjects represented the opposite extremes of mean duration within the experimental group on the /s/ singleton measure, with Subject M2 performing more like the normal subjects on both mean duration and intrasubject variability than any of the other three experimental subjects. However, on the /s/

cluster measure, Subject C1 demonstrated the mean and intrasubject variability most like that of the normals. The [s] duration measure, revealed essentially equivocal results across treatment types at the 50% production accuracy measuring point.

On both the vowel to vowel measures and the [s] duration measures then, the experimental subjects demonstrated longer mean durations than did the normal subjects for both singleton /s/ environments and clustered /s/ environments. Additionally, all of the experimental subject's mean durations on the vowel to vowel measure were greater than they were at pre-treatment except for Subject C2's [s] singleton mean. Relative intrasubject variability differences between the misarticulators and the normal subjects were not as great on [s] singletons for the vowel to vowel measures as they had been at pre-treatment for two subjects. On the [s] singleton [s] duration measures all four misarticulators were similiar to the normal subjects on relative instrasubject variability. Relative intrasubject variability for [s] clusters was greater for the misarticulators at this measuring point on the vowel to vowel measure relative to pre-treatment, so that the misarticulators were more different from the normal subjects at the time of this measure. On the [s] duration [s] cluster measure three of the experimental subjects were exhibiting greater relative intrasubject variability than the normal subjects. It would appear that though the experimental subjects exhibited greater mean durations on all measures at the 50% production accuracy measuring point relative to the normal subjects, their greater relative intrasubject variability on [s] clusters suggests that the [s] cluster contexts were the least stable productively.

Three experimental subjects on their vowel to vowel mean durations for /s/ singleton environments shared the same range of mean duration exhibited by all of the experimental subjects on the [s] duration measure for /s/ singleton environments. However there was no overlapping of mean range on the same across measure comparison for /s/ cluster environments. These same relationships were exhibited by the normal subjects on these same across measure comparisons.

At the time of this measure, the subjects were producing clearly perceptible [s] sounds with at least 50% accuracy. Though they were effecting duration differences at the pre-treatment point, at this 50% point in time they were evidencing more use of more features of /s/ besides just the duration feature. For example, at this point they were incorporating the feature of frication which was clearly apparent perceptibly and was visibly apparent in spectrographic representations of all four experimental subjects. Informal visual inspections across a few of each subject's spectrographic representations indicated considerable variability across subjects in relative intensity and spectral range of fricative energy. Subject C1, for example in spectrographic representation of intervocalic /s/ singleton revealed clear and sequential fricative energy concentrations corresponding to and proceeding from [s] to [h] to the vowel. They were each then using some different articulatory gestures to effect the specific feature of frication, in contrast, or perhaps in addition to whatever gestures they used at pre-treatment to effect duration differences. Since a systematic analysis relative to specific spectral characteristics in the data used to obtain duration measures has not yet been performed, it is not known whether subjects were still using their previous articultory patterns to achieve duration differences in their non-fricative [s] attempts or not.

TERMINAL STAGE

At the end of treatment, the motor speech measures and perceptual tasks were conducted for the last time. These will be discussed first, and then discussion will focus on other aspects of the findings and how these findings may be viewed in order to better understand the nature of the misarticulator's speech errors, and the subsequent remediation of these errors.

Comparison of Experimental Subject's Post-Treatment Speech Motor Performance with That of the Normals

Performance on Vowel to Vowel Duration Measures

The experimental subjects differed from the normal subjects at the post-treatment measurement point in that their absolute mean [s] singleton and [s] cluster vowel to vowel durations were longer than those in the normal group. The experimental subjects were similar to the normal subjects in that their respective [s] cluster mean durations were longer than those of their [s] singletons. Despite their differences in absolute mean durations, all four of the experimental subjects did reduce their [s] singleton and [s] cluster mean durations from the 50% accuracy of production level so that they tended more toward the normal range. Each reduced his relative intrasubject variability about his respective mean durations for [s] singletons and [s] clusters so that they fell within the range of the normal intrasubject variation values.

Performance on [s] Duration Measures

The experimental subjects differed from the normal subjects in their respective absolute mean [s] durations in that theirs were longer than the normals for both the [s] singleton and [s] cluster measures. They also differed in that their range of means was greater than that of the normal subjects. The normal subjects' range of means was 38 msec extending from a low of 123 to a high of 161 msec. The low and the high for the normals were [s] cluster mean durations though one of the singleton means was almost identical to the lowest cluster mean. The experimental subjects' range of means for [s] singleton mean durations was 251 msec, extending from a low of 173 msec to a high of 424 msec. Their range of means for /s/ clusters was 142 msec, extending from a low of 204 to a high of 346 msec. If Subject M1 were excluded from the cluster range however, the range would be only 5 msec extending from a low of 204 msec to a high of 209 msec. All four subjects reduced relative intrasubject variability on /s/ singleton and /s/ cluster measures, to the extent that they fell within the range of the normal intrasubject variation amounts.

Summary of Performance on Speech Motor Measures at Post Treatment

The experimental subjects differed from the normal subjects on motor speech measures at the end of treatment. These differences were manifested in the greater magnitude of the experimental subject's respective means for [s] singleton and [s] clusters on both the [s] duration and the vowel to vowel measures.

There were similarities between the normal subject's performances and those of the experimental subjects, however, in that on the vowel to vowel measures, the experimental subjects demonstrated longer [s] cluster mean durations than [s] singletons which was also the case with the normal subjects. Additionally, on most measures, most of the experimental subjects did exhibit trends which were more toward normal in that they were reducing the magnitude of their respective mean durations and intrasubject variability over time from mid-treatment to post-treatment. One subject M1 exhibited the greatest mean durations, and though he did follow the normal trend in reductions in mean durations and intrasubject variability on the vowel to vowel measures he increased his means on [s] duration for [s] singletons and for [s] clusters. Subject C2 increased his mean durations in /s/ duration measures from mid-treatment to post-treatment.

Over the course of investigation of motor speech abilities in the experimental subjects relative to the normals, it is clear that differences were evidenced by the misarticulators from pre-treatment to terminal criterion when compared to the performance of the normal subjects. The differences were manifested between the two groups at the pre-treatment point in both absolute magnitude of mean [s] related durations, greater relative within group variability, and greater relative intrasubject variability on the vowel to vowel measures; and in the relationship of

[s] cluster duration to [s] singleton durations. At the 50% accuracy of production level and terminal criterion levels, the absolute magnitude differences remained essentially stable across the two groups, though improvements had occurred across all four of the misarticulators in terms of direction of change in mean duration and relative intrasubject variability for [s] singletons on the vowel to vowel measure, and in all four in terms of relationship of /s/ clusters to /s/ singletons on the vowel to vowel measures, relative to the performance of the normal subjects.

Despite the presence of the duration differences however, correct [s] productions were attributed to all of the experimental subjects at their respective relative production accuracy levels on the basis of phonetic transcription of their productions. Further, clinical judgment on all four subject's performances on their respective connected speech probes was that each had successfully achieved correct [s] production, relative to the terminal criterion.

Weismer and Elbert in their study of functionally misarticulated [s] in 4-6 year old children suggested that the differences observed between the misarticulators and the normal subjects used in their study were due to "differences in speech motor control capabilities" (1982, p. 275). The present study differed in several ways from that of Weismer and Elbert, primarily in regard to type of misarticulation, collection of data on motor speech performance over time from pre-treatment through correct production, and acoustic analysis methods. Their subjects exhibited a fricative error, [θ/s], so those subjects had already organized a similar representation of /s/ in terms of their respective feature sets, relative to certain lexical forms, as evidenced by their productions. Additionally, their subjects had not been diagnosed as exhibiting articulation disorders, and could have been, according to Weismer and Elbert, in the process of normal articulation development (p. 278).

In the present study, as previously mentioned, the misarticulating subjects were unintelligible speakers at the outset of treatment, and they demonstrated definite motor speech differences on measures of [s] duration relative to the normal subjects. In the discussion on motor performance at pre-treatment it was suggested that the motor differences at that point might have reflected cognitive level operations relative to organizing the phoneme feature set of /s/, rather than necessarily originating at lower motor levels. Similarly, it is suggested that the relative duration and variability differences exhibited by the misarticulators at both the mid-treatment and post-treatment measures, may have been explained, at least in part, on the basis of cognitive level organization processes relative to their respective versions of /s/, relative to certain lexical shapes. The trend of sensory motor changes toward normal performance may have been representing the progressive refinement of articulation gestures necessary to effect stable [s] production across the varying contextual demands, since the experimental subjects' productions when considered "corrected" were still different, though improving. The interaction of developing stored target forms and the ordering and coordinating of motor plans, as well as information derived from auditory and proprioceptive feedback mechanisms during production are all relevant factors, which require further investigation.

It is not possible to determine to what degree either cognitive or motor level factors contributed to the sensory motor differences. As suggested earlier, additional spectrographic analysis of the mechanisms of change is indicated, particularly on a case by case basis. It would be particularly helpful if motor speech measures like those in the present study were conducted after subjects had stabilized their [s] production at a 90% criterion or better for perhaps four to six weeks. At that point, it would seem that the representation of /s/ would have been well established and that whatever differences remained would indicate motor level differences. Additionally, a larger number of subjects who demonstrate this particular error pattern should be studied over time.

The interpretation of sensory motor differences as stemming in part from a cognitive origin is consistent with observations of the performance of the misarticulating pre-schoolers in the present study compared with the performance of their normal peers, and is consistent with other previously mentioned research which has been concerned with the nature of misarticulation, and phonological change. The findings in this study were somewhat different from those in the Weismer and Elbert study, first the normal subjects in this study exhibited similiar relative intrasubject duration variability between [s] clusters and [s] singletons on the vowel to vowel measure, which was the measure that was most similiar in terms of overall duration to theirs. Second, it was only at the 50% accuracy of production measuring point that the experimental subjects exhibited greater relative intrasubject variability in [s] cluster environments relative to singleton [s] environments. Also, at this point the experimental subjects all demonstrated greater mean durations of [s] in clusters than in singleton environments. At post-treatment, these experimental subjects demonstrated similiar intrasubject relative variability across both phonemic contexts, and were similiar to the normal in this relationship. Additionally, these subjects exhibited similiar relative intrasubject variability to the normals at post-treatment. Weismer and Elbert only studied their subjects at one point in time. Additionally, the nature of the error for /s/ that they investigated was significantly different from that in the present study. The suggestion made in this investigation that motor differences may not be indicative of only motor level function is not meant to discount the role of motor control in these misarticulators. It is assumed that developing phonological systems require developing motor targets, which subsequently require motor level refinements.

Changes in Perceptual Task Performance in the Experimental Subjects at Post-Treatment

On the auditory identification measure there were no differences in gains made across the two groups on the word final /s/ vs /t/ vs /k/ task. On the word initial contrast however, the cognitive approach subjects gained a fairly equally distributed 13 point gain, whereas the sensory motor approach subjects gained four points and one point each. Only one of the points gained on either task however, by an experimental subject was an /s/ item. This gain was made by C2 on task 2.

On the auditory discrimination task, however, the results appeared more subject specific than treatment related. One subject M2, had demonstrated perfect scores on both tasks at pre-treatment, so positive change wasn't possible for her at post-treatment; she did however lose a point on the cluster vs singleton discrimination task. Subjects M1 and C2 each gained on each task, with the same total gain. Subject C1, the youngest didn't change on the stop-continuant contrast with singletons and lost one point on the cluster vs singleton task.

The cognitive approach subjects demonstrated the only real gain on the auditory perception tasks, and that was on the auditory identification measure. Though consistent with the basic thrust of the cognitive approach, i.e. making the child aware of contrasts, the changes were not particularly relevant to the purposes of the study, since they were within the stop phoneme category and not between stops and continuants.

Performance Of the Experimental Subjects Relative to Attaining Terminal Criterion

The main question addressed in this investigation was whether or not treatment type differentially affected the amount of time, operationalized as the number of treatment sessions, necessary for a misarticulating child to reach a pre-determined level of production accuracy of [s]. This study set the terminal criterion as that session during which the child achieved a level of 75% production accuracy on the second consecutive connected speech (spontaneous speech level) probe. Using this criterion then, Subjects C1 and M2 attained terminal criterion prior to their respective matches. However, the results are not as equivocal as they appear.

In the case of the first treatment pair, Subject C1 finished in thirteen fewer sessions than his match Subject M1. Both of these subjects attained final criterion on the second consecutive session after reaching the 75% accuracy in connected speech for the first time. In this case then, the final criterion application was uncomplicated.

However, in the case of the second treatment pair, the attainment sequence was different. Subject M2 performed like Subjects C1 and M1 in the way she attained final criterion in that her second consecutive 75% accuracy of production on the connected speech probe was the actual second instance in which she reached that level of productive accuracy. Subject C2's sequence was different. His sequence of percentage of accuracy scores on the connected speech probe proceeded as follows beginning on the 35th treatment session (session numbers appear in parentheses): (35) 68%; (38) 70% (41) 75%; (44) 73%; (47) 73%; (50) 88%; (52) 90%. It is important to note that the difference in real numbers between the 73% and the 75% level of accuracy of production was one probe item. Subject C2's match, Subject M2, attained criterion on her 46th treatment session. This was accomplished after the following scores: (35) 50%; (38) 63%; (41) 68% (44) 86%; (46) 80%.

The "difference" between the attainment of final criterion in the second pair of subjects is not clear. From a clinical standpoint it would be difficult to justify having a child continue for eight additional sessions beyond the 44th because of a similar one item difference. It would appear equally as difficult to find support for the real superiority in treatment methods between the two members of this pair on the basis of a direct comparison between their successive scores. Further, in clinical application, a clinician would also have to take into account the real dollar cost to the client on the basis of such a decision.

If a range of performance was used as a final criterion, such as 70-80% production accuracy over three successive connected speech probes (which would span at least a week) sessions had been used then Subject C2 would have attained criterion on the 44th session while M2 would have attained it later on her 49th session at which point she produced 83% of the connected speech probe correct. In the case of the first pair, M1 would have attained criterion on the 77th and C1 on the 64th session, still a thirteen session difference.

Diedrich and Bangert (1980) suggested that in /s/ remediation, the 75% criterion for two successive probes be used for dismissal, and it was intended that the probes be one week apart. If Diedrich's criterion had been used with the one week stipulation, in the present study, then Subject C1's first 75% occurred on the 60th session two days earlier than his terminal criterion. One week or more later would be the probe that was completed on the 64th session ten days later. C1 never slipped below 75% once he attained it the first time. Subject M1's present criterion on the 74th session met Diedrich's criteria. Therefore in the first pair, there would be a ten session difference rather than the present 13 session difference, though the results would be the same in terms of who finished first, and the difference would still be a substantial one. In the second pair, Subject M2's present criterion would meet Diedrich's criterion, while C2's present terminal criterion would also meet Diedrich's criterion.

Even using Diedrich's criterion, the same problem exists in the relative nature of the difference for the second pair. Subject C2's first 75% accuracy of production occurred ten days prior to his 73% accuracy level, which occurred two weeks prior to a 73%, and then again one week later the 88% (nine session span). Obviously this subject had stabilized his [s] production accuracy. The point behind this discussion is that of emphasizing the relative nature of the final criterion in terms of its interpretability for normal clinical purposes. The difference in the first pair in terms of who finished in fewer sessions is clear. Since the cognitive subject in the second pair attained 75% production accuracy first and essentially maintained that level of performance it would appear that from a realistic and clinical point of view that the cognitive approach was the more efficient of the treatment types with regard to learning rate of /s/.

Further clarification may be found in the application of the assumptions about the findings. If the terminal criterion were to be accepted without question, then it would have to be concluded that in this study there was no substantial demonstrable advantage of one treatment type over the other in terms of time spent in remediation. However, when considering other factors related to the two treatment approaches such as the number of responses per session (determined by the clinician); nature of the interaction (imitative drill format vs interactive communicative play situations), and the developmental level of the misarticulators, another interpretation emerges. If there was no demonstrable difference between the four misarticulator's learning rates relative to the two treatment approaches, developmental considerations and the similarity with the normal communicative process would suggest the cognitive approach as the more realistic, potent, and useful method. All levels of language production are stimulated in the cognitive approach as compared to the stimulation of the auditory-motor loop in the sensory motor approach.

Further support for this position is found in the fact that if, in one pair the child in the cognitive approach finished 10-13 sessions sooner than the child in the sensory motor approach; and, if in the other pair there was a reasonable question as to which one finished first, then there is no clear support for the motor approach having been the more efficient in this investigation. Both sensory motor approach subjects would have needed to finish first in order to have demonstrated the relative advantage of the different components of the sensory motor approach over the cognitive approach procedures. The nature of the closeness of the production accuracy in both subjects in the second pair when the first child, M2 attained final criterion, would not be consistent with the expectations behind the sensory motor approach regarding its emphasis on great amounts of practice in the remediation of misarticulation. Nor did this finding support the relative advantage for the highly structured drill format which was invoked. With all aspects considered regarding developmental appropriateness and similiarity to the real communication process, the cognitive approach appears to have been the more efficient.

Production Accuracy in Single Words Relative to Connected Speech at the 75% Production Accuracy level

All four experimental subjects attained the 75% accuracy of production level at essentially the same time at both the single word stimulus level and at the spontaneous speech level. This observation is based on the finding that the four attained this production accuracy on the two probe types within one probe alternation cycle, respectively. This particular finding taken in conjunction with the finding of no differences across treatment groups at the 25% production accuracy level does not support any relative advantage of the progressive stages of complexity stressed in the sensory motor approach in the present investigation. It would have been expected that if the progressive stage model advocated by such traditionalists as Van Riper, and McDonald were the more accurate theory for explaining the misarticulations exhibited by the children in the present study, then the children in the sensory motor approach would have performed differently. They would have attained their respective 75% accuracy of production at the single word level considerably earlier than at the connected speech level. Ruscello (1984) has observed a shadow effect on the relative performance of treatment subjects on formal Speech Production Tasks (SPT's) and spontaneous tasks. The SPT's as used in a number of studies (Elbert, Shelton, Arndt, 1967; Diedrich and Bangert, 1980) are composed of the target sound produced in traditionally oriented levels of progressive difficulty; i.e. sounds, words, and phrases. In the present study, the speech probes used consisted of only two types, single word stimuli composed of single syllable words; and a connected speech probe in which the child is given the same word stimuli and asked to talk about each spontaneously. Additionally, the SPT's used by others have incorporated McDonald's systematic contextual variations. No such constraints were used on the probe in the present study.

Perhaps another way of looking at this issue would be that from a traditional articulation remediation point of view, at least the misarticulators who did not experience the traditional sensory motor progression in treatment would have been expected to perform differently from those who did. However, the subjects in both approaches performed the same relative to the similarity of timing in attaining their respective terminal levels of production accuracy in single words and in connected utterances.

Syllable Shape Emergence At the Single Word and Connected Speech Levels

It may be that the analysis of the total 75% accuracy of production by single word and connected speech without regard to position of the sound in the word is too broad an analysis to reveal differences expected under the traditional theory. The subjects in the motor approach were taught to produce the /s/ in a given order of syllable shapes, and the syllable shapes were each taught in stimuli which were systematically lengthened in terms of syllable length depending on the subject's previous performance. Structural complexity of the stimuli was also controlled. Therefore, the same breakdown of 75% production accuracy in single words and connected speech by sound position in the word such as word initial or word final should reveal differences across the two treatment groups, if the traditional assumptions of relative importance of progressive steps in stimulus length and complexity, and practice provide a learning advantage in the treatment of misarticulation (Ruscello, 1984).

Word initial /s/ was examined in the development of /sV-/ lexical/syllable shapes and word final /s/ was examined in the development of /-Vs/ lexical/syllable shapes by each misarticulator since these were the shapes performed by all of the subjects at the 75% level of production accuracy. Each subject attained the 75% production accuracy level in the /sV-/ single word probe and connected speech probe within the following number of alternation probe cycles: M1, one probe cycle; C2, five probe cycles, and C1, three probe cycles. Subject M2, attained the 75% production accuracy in connected speech two probe cycles ahead of single words. For the /-Vs/ lexical shapes the following held: M1, seven probe cycles; M2, seven probe cycles, C2, six probe cycles, and C1, one probe cycle.

These findings suggest that, for the word final /s/ singleton, one cognitive approach subject did as well as the sensory motor subjects and one cognitive approach subject did the best of all four. For the word initial /s/ singleton, one motor subject performed according to traditional expectations relative to the performance of his match in the cognitive approach; however, one motor approach subject reversed the predicted sequence and attained the accuracy of production in connected sentences at the 75% level two probes ahead of the single word level. Even though the sensory motor subjects did achieve their accuracy of production levels between single word and connected speech faster than the subjects in the cognitive approach on word initial /s/, the results of both analyses taken together do not provide the type of general support in this investigation that would have been expected to demonstrate a relative advantage of the sensory motor approach over the cognitive approach.

Average Number of Responses by Treatment Type

One of the main points of emphasis of the traditional approaches is that of the importance of practice in the development of speech sound production (Shelton and McReynolds, 1979; Kent, 1981; Ruscello, 1984). Since speech is viewed primarily as a motor skill in the traditional motor approaches practice of the newly acquired sound is stressed (McDonald, 1974; Goldberg and Mathers, 1984). Despite the fact that the sensory motor subjects in the present study experienced an estimated average of 4-5 times the number of /s/ related responses per session over the subjects in the cognitive approach, one of the cognitive subjects finished well ahead of his sensory motor match, while the other cognitive approach subject attained a level of 75% production accuracy prior to his motor match. Practice itself has been described as a component of speech change and remediation that varies according to the individual. If the misarticulators in the present study required motor skill development in the way of practice in a drill format to correct their [s] productions, the results would have been expected to favor both of the children in the sensory motor approach. This was not the case. The results of this study would seem to argue against motor skill as the primary limiting problem in these misarticulator's acquisition of [s].

Learning Patterns Evidenced in the Experimental Subjects

Overall learning patterns exhibited by the four experimental subjects which encompassed the entire treatment progression, revealed that subjects M1 and C1 exhibited relatively protracted learning curves when compared to those exhibited by Subjects M2 and C2. Traditional sensory motor theory regarding articulation remediation would not have predicted the relative performance exhibited by C1 in contrast to M1 on attaining minimal accuracy of production in connected discourse, considering the differences in the treatment approaches. Nor would sensory motor theory have predicted the across treatment similarities exhibited within both treatment pairs relative to overall learning curves.

It has been reported that learning transfer, or generalization, is greater for "known" sounds than for "unknown" sounds (Dinnsen and Elbert, 1984). Elbert and Gierut (1986) have noted that "...phonological knowledge affects the amount, extent, and type of generalization learning that a child may exhibit (1986, p. 130)". In terms of /s/ generalization, it might have been predicted that the children who exhibited the most knowledge of sounds related to /s/, in particular other fricatives, would have been able to generalize faster on the basis of distinctive feature generalization. At pre-treatment, all of the subjects exhibited duration aspects that suggested they might be aware of the duration differences in /s/ vs stop consonants. However, two of the subjects, C1 and M2, were in fact producing correct fricatives other than /s/, though M1 and C2 evidenced no correct fricative productions on any of their phonetically transcribed pre-treatment productions. The two who corrected /s/ the earliest in their respective treatment pairs were Subject C1 and Subject M2, relative to terminal criterion. It is possible then that in the first pair, C1's greater "knowledge" revealed in productions of fricative class consonants may have been a determining factor in his earlier correction of [s]. The case in the second pair is not so clear, once again since the two were so close in attaining terminal criterion. In terms of rate of [s] correction across all four subjects, M2 and C2 attained terminal criterion in fewer sessions than either M1 or C1. This last result is not what was predicted on the basis of distinctive feature generalization.

Another learning pattern that was evidenced in this study appears to somewhat contradict the notion of generalization being a function of greater knowledge of the sound system as just described, at least on the basis of distinctive feature knowledge in regard to fricatives. As just mentioned, Subject M1 and C2 evidenced no correct fricative productions in any pre-test measures. Nevertheless, at the end of treatment all four subjects exhibited correct productions of [s,z,f,v,ʃ] and [ʒ], except C1 who did not exhibit [ʒ]. Further, the subjects who demonstrated the greatest overall number of non-targeted sound corrections were M1 with nineteen, and C1 with eighteen corrections. Subject M2 corrected fifteen productions, and C2 corrected eleven productions. In terms of absolute gain, the two subjects who were in treatment the longest effected the greatest number of corrections.

In terms of overall rate of learning, the two treatment pairs appeared fairly equally balanced at the outset of treatment in that each treatment pair contained a child who exhibited knowledge of frication in correctly produced fricatives and one who produced no fricatives. All four misarticulators performed as similarly as could be determined on the pre-treatment measures relative to /s/. The clinician was the same for both pairs, and the pair that corrected /s/ the earliest, M2 and C2, were seen in the least optimal surroundings with regard to noise levels, and other distracting influences for a large part of their respective treatment programs.

Subjects C2 and M2 were described as the two most similar in terms of general behavioral compliance relative to treatment tasks. Subjects C1 and M1 were the two who demonstrated frequent explicit task rejection behaviors, in contrast to the other two subjects, who characteristically did not do this. Though no formal measure was performed to assess these relative differences in terms of "task readiness" or "behavioral appropriateness" for learning in the treatment situations, the two pairs were observably different in this area of behavior, as described in Chapter Three, and were characteristically so over the course of treatment.

Implications for Further Research

Three major issues were addressed in this investigation: whether or not motor speech differences existed in the pre-school misarticulators who produced stop consonants for [s] and normally articulating peers; whether or not there were perceptual differences between these misarticulators and the normal children on auditory perceptual measures involving the stop-continuant contrast; and whether or not there were differential effects of treatment type relative to the different theoretical assumptions. Questions which were raised in the discussion of findings suggested areas for future research which would provide further insights into the nature of such misarticulation patterns as "stopping" and "cluster reduction" and the processes responsible in the correction of these patterns in pre-school populations.

Though it was revealed that the misarticulating subjects in the present investigation demonstrated motor speech differences when compared to the normal subjects, from pre-treatment through correction of /s/, more information is needed relative to the nature of the motor differences. It was suggested in this study that the differences in the group studied may not be due to motor level differences only, particularly at the pre-treatment point, at which time it was suggested that the motor differences might have been representing cognitive level operations related to organization of specific phonemic contrasts, which is consistent with a development model of phonological knowledge. This assumption was based primarily on the basis of duration differences effected by all of the misarticulators at pre-treatment relative to the three different phonemic contexts sampled. Spectrographic analysis of the specific acoustic phenomena, arising from articulatory gestures, such as manipulation of the closure and burst release periods and the presence of multiple spikes which effect the duration differences is needed. Other features such as frication may be evidenced on closer analysis. If a given child were to use regular types of articulatory gestures to effect duration at a pre-treatment level it would suggest that he was using certain "strategies" to effect a particular feature of importance. Similarly, analyses at the 50% accuracy of production level for all /s/ contexts would be helpful to determine whether the child is using the same or different mechanisms entirely for productions whether they contain other features such as frication or not. Additional sensory motor measures should be performed in pre-school misarticulators who exhibit the same error forms after a level of 90%-100% accuracy has been maintained in connected speech over multiple consecutive probes spanning several weeks. Differences observed at that point in time in formerly misarticulating subjects would suggest motor level differences.

Future analyses should include a greater number of subjects who exhibit this particular pattern, and should once again be conducted over time through correction so that the developmental nature of the changes may be appropriately accounted for. Replication research is suggested due to the small number of subjects involved in the present study. In future treatment studies on pre-school misarticulators who exhibit severe unintelligibility, as well as stopping for continuants, specific charting of explicit behaviors relative to task resistance/ task acceptance, as well as analysis of parent/family management and interaction behaviors should be performed.

General Conclusions

In the present investigation, the presence of duration differences in phonemically different targets which were perceptually categorized by adult listeners as the same phonetic productions on the part of misarticulating pre-schoolers suggested that the misarticulators were in fact attempting different targets. These misarticulators exhibited sensory motor differences as indicated by duration measures of speech production, with normal subjects of the same age. These differences which were manifested at three different points in time by the misarticulators suggested the input of cognitive level organization of features for /s/ as at least a partial basis for the motor differences, particularly at pre-treatment. This same influence was suggested at the 50% level of production accuracy in the misarticulators on their motor speech measures. Motor level components were indicated particularly at the post-treatment point when transcription of the misarticulator's respective /s/ productions indicated they were correct 75% of the time. The findings of the present investigation relative to acoustic differences exhibited by misarticulating pre-school children on the error sound, which are imperceptible in phonetic transcription, are consistent with previous findings on different articulation errors.

Though the small number of subjects and lack of specific spectrographic verification preclude generalization at present, the consistency of the findings of motor differences evidenced in duration differences suggest that other explanations besides differences in motor control capabilities should be considered.

The two subjects who experienced the sensory motor treatment approach did not demonstrate a markedly faster attainment of /s/ correction relative to the two subjects in the cognitive approach. In fact, the performance of the cognitive subject in the first treatment pair was substantially better than his sensory motor match; while the other cognitive subject attained his first 75% level of production accuracy ahead of his sensory motor match. Because of this finding, it is suggested that the assumptions which were the basis for great amounts of phonetic practice through drill, and step by step levels of progressively more difficult stimuli were inadequate in explaining the nature and treatment of the misarticulations in the subjects in the present study.

The subjects in the present investigation did not exhibit auditory perceptual differences relative to the normal subjects on the perceptual tasks. Further, there was little evidence in the misarticulator's perceptual task performances that appeared to be related to their /s/ misarticulation.

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APPENDIX A

College of Arts and Sciences
Department of Speech Communication,
Theatre and Communication Disorders
LSU Speech and Hearing Clinic

LOUISIANA STATE UNIVERSITY AND AGRICULTURAL AND MECHANICAL COLLEGE
BATON ROUGE · LOUISIANA · 70803-2606
(504) 388-2545

Dear Parent:

I am conducting a research study on speech sound learning as a partial requirement for my doctorate in communication disorders at Louisiana State University. I will be conducting the study here in Beaumont where I reside and am seeking children who would be good candidates for the study.

The following is a criteria for children that are required:

- the children should pronounce some speech sounds incorrectly;

- children should be between 3 years 8 months and 5 years 6 months of age at the time of their participation and come from English-speaking homes;

- children should not have had any previous speech therapy.

In order to determine whether a child can participate, an initial screening and parent interview will be conducted. Depending on those results, the child may then receive the following:

- hearing testing
- language testing
- intelligence testing
- in-depth speech testing and analysis

If the child meets the requirements of the study following such testing, he/she may then be a participant. The selection process will continue until such time as a sufficient number of children have been selected to meet the needs of the study. All testing and any therapy will be conducted at no charge as this is a research study.

If you feel you would be interested in having your child participate, please contact me here in BEAUMONT at 899-4099 (day) or 833-1948 (day or evening). I will be happy to answer any questions about the testing and/or the program.

Sincerely,

Elizabeth Lathrop Lee

Elizabeth Lathrop Lee, M.S., C.C.C.
Speech-Language Pathologist

College of Arts and Sciences
Department of Speech Communication,
Theatre and Communication Disorders
LSU Speech and Hearing Clinic

LOUISIANA STATE UNIVERSITY AND AGRICULTURAL AND MECHANICAL COLLEGE
BATON ROUGE · LOUISIANA · 70803-2606

(504) 388-2545

Dear Parent:

We would like to obtain your permission to include your child, ______________________, in an articulation study. In this study we are attempting to obtain information about the relationship between speech sound error patterns and methods of remediation. We are concerned with the child who does not always use certain sounds correctly.

Each child must meet several criteria to be included in the study. In order to determine whether or not your child would be able to participate, we will need the following information:

1. Your written permission for testing and possible inclusion in the study.

2. Completion of a questionnaire and developmental history form about your child.

3. Preliminary speech screening to determine whether your child demonstrates the speech pattern required for this study.

If, following the above procedure, it is determined that your child might demonstrate the speech pattern required, then the following evaluation will be performed to determine whether or not he/she can be included in the study:

- Hearing screening
- Language screening
- Examination of the oral speech mechanism
- Non-verbal intelligence testing
- Thorough speech testing and analysis involving tape recording

If, after this testing, your child is selected for inclusion in the study, he/she will be scheduled to attend sessions on a regular basis up to three times a week. During that time, ongoing speech samples will be recorded by audio and videotape for later analysis. Your child will receive one of two therapy approaches, both designed to remediate speech sound errors. The therapy sessions will continue only until the sounds of interest in this study have been remediated. The data obtained from your child's participation will be used to improve our understanding of the relatioship between certain speech sound errors and certain types of remediation approaches.

When sufficient data has been obtained on a number of children, the results will be written up in a research report. Your child will not be identified in any way other than as a subject number. Complete confidentiality will be maintained.

You are invited to discuss any aspect of the study with me and to observe the remediation sessions. The remediation sessions should be beneficial to those children who participate and should result in improved articulation skills and better overall speech. All sessions are free of charge.

As the information obtained in this study should enhance our understanding of speech errors and methods used to treat them, I would like to express my appreciation for your willingness to cooperate in this effort.

Sincerely,

Elizabeth Lathrop Lee, M.S., CCC/Sp-L
ASHA Certfied speech-language pathologist

ELL:bk

* * * * *

I (do) (do not) give permission for my child, __________ ______________________, to be tested for possible participation in the research study conducted by Elizabeth Lathrop Lee on sound learning.

____
Signature of Parent/Guardian

____
Date

BEAUMONT INDEPENDENT SCHOOL DISTRICT
Beaumont, Texas

APPLICATION FOR APPROVAL TO CONDUCT A RESEARCH PROJECT
IN BEAUMONT ISD

SUBMITTED BY: Elizabeth Lathrop Lee (Phelan) DATE: 10-27-87
month/day/year

Description of proposed research project.*
This is my dissertation research project for my doctorate in speech-language pathology at Louisiana State University. The study is a comparison of treatment effectiveness between two approaches to the remediation of articulation errors in young children. Children receive intensive individual therapy in either a motor-based articulation approach or a cognitive-linguistic approach.

School level to be used (check appropriate).

X Pre-Kindergarten
___ Elementary School
___ Middle School
___ High School
___ Senior High School

Audience/Population (check appropriate).

X Students
___ Teachers
___ Campus Administrators
___ Central Administrators
___ Other (specify) ________.

Source of Funding/Cost (check appropriate).

X Self
___ Grant (describe on reverse side)
___ Institution/Association (describe on reverse side)
___ Other (describe on reverse side)

Proposed project dates:

Began June 1987 beginning — month/day/year
12/30/88 ending — month/day/year

Approval (obtain appropriate signatures):

Claud Collier — Campus Principal — 10/27/87 Date

Jack Kennedy — Research & Evaluation Director — 10/27/87 Date

Superintendent — 10/28/87 Date

JK/ahm

*Please supply Research & Evaluation with a copy of the final draft of project.

APPENDIX B

Speech Probe Words:

soup
stop
seat
us
boxs
same
spot
goose
lips
house
side
fix
snap
bumps
set
hops
swim
speak
fox
nice
slip
seen
kiss
smoke
tops
sent/cent
piece
saw
hooks
geese
skip
sound
swing
bats
sky
hats
say
miss
lace
vase

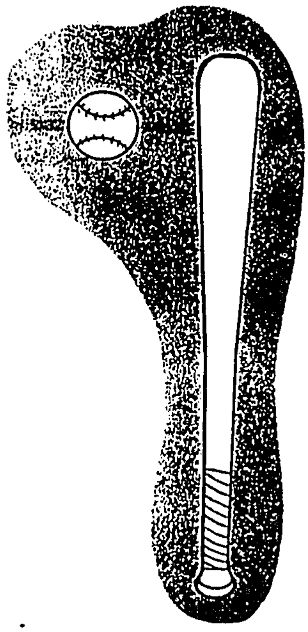
Motor Speech Stimuli

1. my soup
2. I stop
3. a seat
4. the same
5. the spot
6. my side
7. I set
8. I speak
9. be seen
10. I sent
11. I saw
12. I skip
13. a sound
14. the sky
15. I say

APPENDIX C

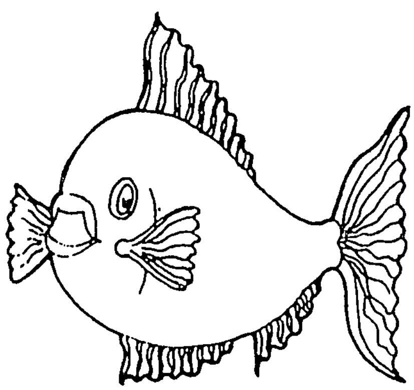
AUDITORY IDENTIFICATION MEASURE

TASK 1	Bat	Back	Bass
	1	2	3
	6	4	5
	9	8	7
	11	10	12
	13	15	14
	17	16	18
	19	20	21
	23	22	24
	25	27	26
	30	29	28
TASK 2	See	Tea	Key
	3	1	2
	6	5	4
	7	8	9
	11	12	10
	15	14	13
	18	16	17
	19	21	20
	23	24	22
	25	26	27
	30	29	28



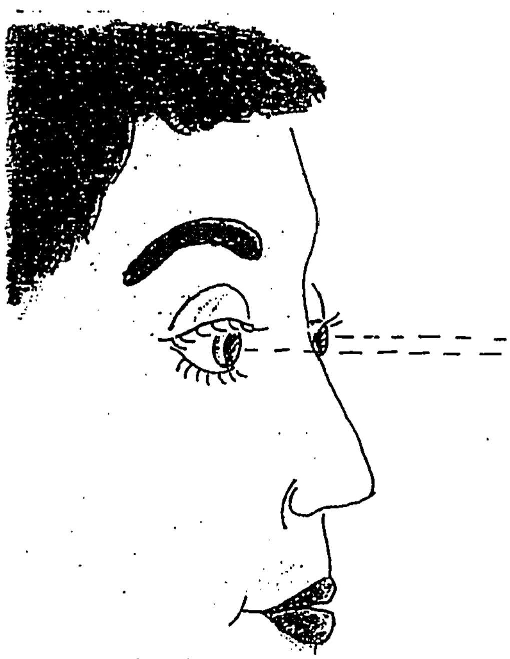
BAT

BACK



BASS

TEA



SEE

KEY

4AIX Discrimination Task 1: discrimination of singleton [s] vs. singleton stop plosive consonant

	Duck puppet (right hand)		Lion puppet (left hand)	
a-1	sisi	_______	siti	_______
a-2	toso	_______	soso	_______
a-3	tasa	_______	tata	_______
a-4	tutu	_______	sutu	_______
b-1	siti	_______	sisi	_______
b-2	toso	_______	soso	_______
b-3	tata	_______	tasa	_______
b-4	sutu	_______	tutu	_______
c-1	siti	_______	sisi	_______
c-2	soso	_______	toso	_______
c-3	tasa	_______	tata	_______
c-4	tutu	_______	sutu	_______

4AIX Discrimination Task 2: discrimination of singleton [s] and singleton [t] vs. [s] + stop cluster

	Duck puppet (right hand)		Lion puppet (left hand)	
a-1	sisi	_______	stisi	_______
a-2	soso	_______	sosto	_______
a-3	sasta	_______	sasa	_______
a-4	tata	_______	stata	_______
b-1	sitsi	_______	sisi	_______
b-2	soso	_______	sosto	_______
b-3	sasa	_______	sasta	_______
b-4	stata	_______	tata	_______
c-1	sitsi	_______	sisi	_______
c-2	sosto	_______	soso	_______
c-3	sasa	_______	sasta	_______
c-4	stasa	_______	tata	_______

APPENDIX D

Treatment Word Stimuli

Primary minimal pair contrasts used in the cognitive approach

Sue	Two
Sub	Tub
Sad	Tad
Sip	Tip
Sock	Tock

Second minimal pair list used in the cognitive approach

seam	team
sack	tack
sail	tail

General word list used in both treatment approaches

ice juice	sit	skates	
dice	seal see	scarecrow	
mouse house	salt soap	skiing	
bus purse	suit sat	scare	
dress moose	sign	school	
rice face	saddle	scarf	
glass	sailboat		
	Santa		
	scissors		
	suitcase		
	sandwich		

slippers	smile	snow	grapes
sled	smell	snake	pants
slide	small	snowman	steps
sleep	smurf	snail	nest
		snoopy	rooster
		sneeze	vest
			Easter egg
			desk
			step
			ducks

spoon	storm	sweater	motorcycle
spider	stairs	swan	castle
spots	star	swing	faucet
spin	stove	sweep	dinosaur
spaghetti	steps		seesaw
	stool		bicycle
	step		glasses
			popsicle
			ice cream
			baseball
			pencil
			icing

APPENDIX E

Table E-1. Relative proportions of treatment period spent by each experimental subject in attaining the minimum (25%) and maximum (75%) production accuracy levels for both single word and connected speech probes

SUBJECT	WORD		SENTENCE	
M1	60	40	62	38
C1	25	75	25	75
M2	52	48	57	43
C2	50	50	50	50

VITA

ELIZABETH LATHROP PHELAN

PERSONAL DATA

Born: March 25, 1948 in Baton Rouge, Louisiana.
Family: married to A. M. Phelan, Jr.
one daughter, Erin Elizabeth Lee, age 14
Address: Home 2445 Long Avenue, Beaumont, Texas 77702
Office 4345 Phelan Blvd, Beaumont, Texas 77007

ASHA certified speech-language pathologist
Texas License # 10645

EDUCATION

B.S. Louisiana State University, 1970.
M.S. Baylor University, Waco, Texas, 1971.

University of Maryland Graduate School, 1982 completed 9 hours graduate work in language acquisition/disorders in children at a joint institute in neurolinguistics, psycholinguistics, and language pathology conducted by the Linguistic Society of America and the American Speech-Language-Hearing Association

PROFESSIONAL BACKGROUND

1971-1973: Bell County Rehabilitation Center, Temple, Texas; staff speech pathologist; diagnostics, therapy; parent counseling.

1973-1974: Capland Center for Communication Disorders, Port Arthur, Texas; staff speech pathologist; diagnostics, therapy; parent counseling; directed pre-school program for the deaf.

1974-present: founded Speech and Language Associates, a private practice, in Beaumont, Texas, serving communicatively handicapped individuals in Southeast Texas area; maintained affilation with the practice and will return to full-time practice in this agency upon completion of the doctorate.

1977-1980: part-time position as clinical supervisor for diagnostic pediatric language program and director of speech and language services for five area Head Start programs at Lamar University, Beaumont, Texas.

1978-1980: served as the parent facilitator for the Port Arthur Independent School District, Port Arthur, Texas and directed the parent education program for parents of children identified as at risk for communication/educational problems.

1980-1983: teaching assistanceship at Louisiana State University; taught undergraduate speech courses.

1981: part-time instructor serving as a clinical supervisor for one semester in the L.S.U. Speech and Hearing Clinic.

1983-1985: part-time adjunct instructor at Lamar University with primary responsibility in teaching the undergraduate and graduate coursework in language acquisition and as clincal supervisor.

1985-1986: full-time graduate assistantship from Louisiana State University for the purpose of conducting dissertation research.

PROFESSIONAL AFFILIATIONS

American Speech-Language-Hearing Association
Texas Speech-Language-Hearing Association
Southeast Texas Speech-Language-Hearing Association; charter member
National Association for Children with Learning Disabilities
Beaumont Association for Children with Learning Disabilities; charter member

DOCTORAL EXAMINATION AND DISSERTATION REPORT

Candidate: Elizabeth Lathrop Phelan

Major Field: Speech

Title of Dissertation: Relative Efficacy of Treatment Strategies For Functional Misarticulation In Pre-School Children: Sensory-Motor and Cognitive Approaches

Approved:

Paul R. Hoffman

Major Professor and Chairman

F. Glen Hemphrey

Dean of the Graduate School

EXAMINING COMMITTEE:

Raymond G. Daniloff

Hugh W. Buckingham

David C. Sloan

Janet A. Norris

Date of Examination:

7/21/89